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Dr. J. W. L. GLAISHER, M.A., F.R.S., PRESIDENT, in the Chair.

George McKenzie Knight, 25 Holford Square, Percy Circus, W.C.,

was balloted for and duly elected a Fellow of the Society.

The following Candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

Thomas Ayres, M.Sc. (Vict.), Student of Astronomy in Strassburg University, 7 Finkermattstrasse, Strassburg, Elsass, Germany (proposed by R. Wilding) ;

Charles William Keighley, Marine Engineer, Cluny Villa, Burlington Lane, Chiswick (proposed by William Schooling) ; and

Henry Norris Russell, Research Student, Cambridge University ; Oyster Bay, N.Y., U.S.A. (proposed by Sir R. S. Ball).

Sixty-six presents were announced as having been received since the last meeting, including amongst others :—

Loewy et Puiseux, Atlas Photographique de la Lune, 6me fascicule (texte et atlas) ; and 22 charts of the Photographic Chart of the Heavens, presented by the French Minister of Public Instruction ; Prof. K. D. Naegamvala, Report of the total Solar Eclipse of January 21–22, 1898, presented by the Poona Observatory ; two stereoscopic pictures of Perrine's Comet, presented by Prof. Max Wolf.

On the Suggestion made by Sir David Gill that the Brighter Fixed Stars are as a whole rotating with respect to Fainter Stars as a whole. *By* H. H. Turner, *D.Sc., F.R.S., Savilian Professor.*

1. In No. 3800 of the *Astronomische Nachrichten* there is a "Preliminary Note on an Apparent Rotation of the Brighter Fixed Stars as a whole with respect to Fainter Stars as a whole," by Sir David Gill. He found on comparing the Cape Catalogues for 1880 and 1900 that the "apparent systematic corrections . . . could not be reconciled by any of the usual hypotheses, such as parallactic motion due to translation of the Sun in space, or systematic error in R.A. depending upon magnitude." He found similar difficulties on proceeding to compare these catalogues with Taylor's Madras (1835) Catalogue, as re-reduced by Downing, and by comparisons with the Cordoba General Catalogue and Gould's Zones ; and considers that we are "driven to the conclusion that the brighter stars rotate, with respect to the fainter stars as a whole, about some centre, or that Newcomb's proper motions and precession do not give star-places which would approximately represent fundamental determinations of the first point of *Aries*, as defined with respect to a much larger number of stars. Even this latter hypothesis would not account for all the facts observed."

2. Such important conclusions are deserving of the earliest possible scrutiny by any independent method likely to throw any light upon them ; and as we have at Oxford material for such a scrutiny, in the shape of measures of photographs extending over nearly ten years, no time was lost in examining these measures for the phenomenon suggested by Sir David Gill. I gratefully acknowledge the help of Mr. F. C. H. Carpenter, of the Durham Observatory, in the preliminary part of this work, on which he spent many hours during a holiday visit to Oxford.

3. The question to be decided, having regard to the material available, is briefly this : Does the "magnitude-equation" of the Cambridge meridian observations, as deduced from our photographic measures, remain constant, whatever be the date when the plates are taken, or does it change with the date ?* A determination of this magnitude equation from photographs taken during the years 1892–9 was given in *Monthly Notices*, vol. lx. p. 3, the

* It is, of course, a distinct disadvantage to have to bring in the Cambridge magnitude equation at all. A much more direct method of attacking the problem would be to take plates of the same regions at different epochs and compare the positions of the stars upon them. But at Oxford we have had to be content, so far, with photographing each region once only; and the Cambridge observations must be used as a connecting link.

assumption being made that the proper motions of stars of any given magnitude are in the mean zero; and that the difference of epoch between the Cambridge meridian observations (about 1880·0) and that of the plates (about 1896·0) had therefore no effect on the result. It is just this assumption which we are now to test. Given a sufficient lapse of time, there is no difficulty in testing it thoroughly, but it was somewhat doubtful whether a sufficient interval was covered by the plates taken at Oxford. They run from 1892 to the present time, about ten years; but as a considerable number of both early and late plates are required to make the comparison effective, and as the plates must also be distributed with some approach to uniformity round the 24^h of R.A., the maximum interval is reduced in practice to four or five years.

4. As a preliminary experiment the residuals Oxford—Cambridge in R.A. (or rather in x-coordinate) were formed for all photographs taken earlier than 1894·0. These were compared with those found in the paper of 1899 November, which referred to a later epoch on the average; and it was found that the deduced magnitude-equation was more pronounced for the earlier results—i.e. *the R.A.'s of bright stars* (*mags.* 5·0 *to* 8·0) *are decreasing relatively to those of faint stars* (*mags.* 8·0 *to* 9·5) *in the belt* $+25°$ *to* $+30°$ *Decl.*

This conclusion, which was scarcely more than suggested by the preliminary work, was confirmed by a more extended inquiry; and it does not seem necessary to give the earlier work, which needs several qualifications. But the conclusion is stated at once to draw attention to the unexpected result that the motion of the bright stars is in the *opposite direction* to that found by Sir David Gill. In his belt of the heavens ($-40°$ to $-52°$) the R.A.'s of the bright stars are *increasing*; and we may also remark here the amount of the increase, which is

$+0^s·0015$ per magnitude per year

as found by a comparison of Cape (1880·0) and Cape (1900·0);

$+0^s·0013$ per magnitude per year

as found by a comparison of Taylor (1835·0) and Cape (1900·0).

It will be seen in what follows that the quantities found at Oxford are very like these in amount, but of the contrary sign.

5. The preliminary inquiries having shown that a more detailed investigation might be profitably undertaken, the dates of exposure of all the plates which had been measured were examined, and it was found that in three zones of plates, $+26°$, $+27°$, and $+29°$, groups could be formed in each octant of R.A. of both "early" and "late" plates, the interval being something like five years on the average. The mean dates of the groups are given in Table I., subtracting 1890·0 in each case.

TABLE I.

Mean Date (subtracting 1890·0) and No. of Plates in each Group.

	Zone +26°.					Zone +27°.					Zone +29°.				
	Early.		Late.			Early.		Late.			Early.		Late.		
	Mean Date.	No. Plates.	Mean Date.	No. Plates.	Interval.	Mean Date.	No. Plates.	Mean Date.	No. Plates.	Interval.	Mean Date.	No. Plates.	Mean Date.	No. Plates.	Interval.
h h					y					y					y
0·0– 3·0	3·6	4	8·0	5	4·4	(4·7)*	0	9·4	2	(4·7)*	5·9	8	11·8	9	5·9
3·0– 6·0	3·6	5	9·6	8	6·0	5·0	13	9·1	9	4·1	6·1	5	11·4	10	5·3
6·0– 9·0	3·2	5	9·5	9	6·3	5·1	15	9·3	7	4·2	6·0	9	11·2	8	5·2
9·0–12·0	3·2	5	9·2	9	6·0	5·1	1	9·6	16	4·5	6·1	7	11·6	13	5·5
12·0–15·0	3·6	7	10·1	11	6·5	5·3	4	9·6	10	4·3	6·3	18	11·4	2	5·1
15·0–18·0	5·4	2	9·6	12	4·2	5·4	5	9·6	15	4·2	5·9	12	11·5	8	5·6
18·0–21·0	3·3	12	7·7	12	4·4	3·5	6	7·8	6	4·3	5·2	15	10·3	5	5·1
21·0–24·0	3·6	12	7 8	1	4·2	4·4	8	8·2	9	3·8	5·0	18	9·3	2	4·3
Sum or Mean		52		67	5·2		52		74	4·3		92		57	5·2

* The mean date for zones +26° and +29° has been substituted.

It will be seen that some of the groups contain only a small number of plates, which is natural, seeing that the work was arranged without any reference to the present purpose. But it will be presently shown that all three zones may be combined, and then this weakness disappears.

6. The measures of these plates were utilised in the following way : from the Cambridge Catalogue (series of the *Astr. Gesellsch.* +25° to +30°, epoch 1875·0) the R.A.'s and declinations have been brought up to 1900·0 and converted into standard coordinates : these are used to determine the plate constants, *i.e.* the coefficients in linear expressions

$$\xi - x = ax + by + c$$
$$\eta - y = dx + ey + f$$

and using these plate constants to correct the measures, residuals are formed (Oxford—Cambridge) for the individual stars. All this is the ordinary course of the work for the Astrographic Catalogue. For the present purpose these residuals were collected into the following groups, according to the star magnitude as given in the Cambridge Catalogue.

TABLE II.

Limits of Magnitude.	Mean Mag.	Total No. Stars. +26°. E.	+26°. L.	+27°. E.	+27°. L.	+29°. E.	+29°. L.
5·0 to 6·9	6·0	60	62	62	80	89	43
7·0 „ 7·9	7·5	151	201	167	189	274	145
8·0 „ 8·8	8·5	546	649	544	651	951	486
8·9 „ 9·1	9·0	543	682	615	678	1126	562
9·2 „ 9·5	9·4	683	801	599	793	1335	534

The "mean mag." for the group was adopted as a standard for reference, and if the mean magnitude for any group came out (say) 6·25, a correction was applied to reduce the result to 6·0, using for the small interval 0·25 our general knowledge of the Cambridge magnitude equation in a manner which needs no explanation. No stars of magnitude brighter than 5·0 were included, for reasons which will be tolerably obvious on inspection of the diagram given in *Monthly Notices*, lx. p. 5.

The totals shown in Table II. will give a general idea of the amount of material available.

7. We may now set down the means of these groups, which form the raw material on which the present discussion is based. The unit of the following tables is 0·0001 of a réseau interval, or 0″·03, or 0ˢ·00222 at 26°, 0ˢ·00224 at 27°, and 0ˢ·00229 at 29°; we may take 0ˢ·00225 as the mean value in R.A. The letters E and L are used to indicate the "early" and "late" plates of Table I.

TABLE III.

Mean x Residual (Oxford – Cambridge) for each group in units of 0″·03 *or* 0ˢ·00225.

Zone +26°.

Octant of R.A. h h	Mag. 6·0 E.	Mag. 6·0 L.	Mag. 7·5. E.	Mag. 7·5. L.	Mag. 8·5. E.	Mag. 8·5. L.	Mag. 9·0. E.	Mag. 9·0. L.	Mag. 9·4. E.	Mag. 9·4. L.
0– 3	+56	+ 4	+85	+34	+18	+21	– 4	–12	–36	–28
3– 6	+37	+46	– 2	+23	+ 5	+24	– 2	– 2	–24	–41
6– 9	+64	+46	+38	+46	+18	+17	– 2	+ 2	–41	–28
9–12	+29	+43	+34	+19	+18	+10	– 8	– 3	–29	–25
12–15	+34	+36	+35	+32	+16	+16	+ 8	– 9	–43	–40
15–18	+90	+71	+44	+37	+14	+14	–10	+ 2	–26	–31
18–21	+44	+56	+34	+31	+24	+16	+ 3	+ 5	–28	–28
21–24	+61	–36	+41	+17	+21	+28	+ 7	+ 7	–32	–17
Mean	+51·9	+33·3	+38·6	+29 9	+16·8	+18·3	– 1·0	– 1·3	–32·4	–29·8

Zone +27°.

Octant of R.A. h h	Mag. 6·0 E.	Mag. 6·0 L.	Mag. 7·5. E.	Mag. 7·5. L.	Mag. 8·5. E.	Mag. 8·5. L.	Mag. 9·0. E.	Mag. 9·0. L.	Mag. 9·4. E.	Mag. 9·4. L.
0– 3	(+70)	+89	(+71)	+72	(+24)	+ 8	(–3)	– 9	(–33)	–38
3– 6	+35	+35	+23	+34	+14	+29	–5	– 3	–35	–43
6– 9	+39	+27	+40	+15	+15	+21	–4	+ 2	–34	–24
9–12	+94	+39	(+26)	+30	+33	+19	–3	–12	–39	–24
12–15	+44	+32	+41	+17	+13	+13	–8	– 4	–54	–32
15–18	+49	+49	+46	+25	+ 6	+11	– 2	+ 4	–25	–35
18–21	+48	+32	+40	+33	+19	+16	–1	+ 3	–26	–27
21–24	+37	+58	+35	+39	+21	+29	+2	+ 2	–27	–30
Mean	+52·0	+45·1	+40·3	+33·1	+18·1	+18·3	–3·0	– 2·1	–34·1	–31·6

Zone +29°.

Octant of R.A. h h	Mag. 6·0. E.	L.	Mag. 7·5. E.	L.	Mag. 8·5. E.	L.	Mag. 9·0. E.	L.	Mag. 9·4. E.	L.
0– 3	+84	+53	+57	+32	+30	+13	− 2	−20	−29	−23
3– 6	+38	+43	+29	+11	+ 6	+ 9	−10	− 5	−38	−22
6– 9	+36	+72	+37	+15	+12	+19	0	+ 2	−32	−23
9–12	+46	+16	+18	+41	+15	+14	−12	− 2	−18	−27
12–15	+36	+ 5	+35	+35	+17	+14	− 5	− 7	−39	−38
15–18	+35	+26	+15	+24	+12	+14	− 4	+ 2	−23	−29
18–21	+49	+18	+35	+34	+21	+13	0	+ 3	−24	−25
21–24	+65	+35	+41	+37	+28	+17	+ 3	−12	−29	−26
Mean	+48·6	+33·5	+33·4	+28·6	+17·6	+14·1	− 3·8	− 4·9	−29·0	−26·6

8. Now in studying such phenomena as have been suggested by Sir D. Gill he insists that "we must give equal weight to groups of stars which are symmetrically distributed in right ascension." To take the simple means of the eight octants in Table III. and compare them does not fulfil this condition; for the intervals (as may be seen by referring to Table I.) are not the same in the different octants, and an octant with a long interval will thus have virtually greater weight. But before proceeding to make this correction we may glance at the *sort* of result we may expect, which will not be very different from that obtained from these simple means, since the intervals are roughly about five years.

TABLE IV.

Approximate Mean P.M.'s in R.A. for five years in units of 0″·03 *or* 0ˢ·00225.

Decl.	6·0.	7·5.	8·5.	9·0.	9·4.
+26°	−18·6	−8·7	+1·5	−0·3	+2·6
+27	− 6·9	−7·2	+0·2	+0·9	+2·5
+29	−15·1	−4·8	−3·5	−1·1	+2·4
Mean	−13·5	−6·9	−0·6	−0·2	+2·5

9. These numbers are sufficient to indicate:

(*a*) The *real* nature of the phenomenon from the fact that there is a sensible accordance between all these zones, which are quite independent.

(*b*) The *sign* of the motion is a *decreasing* R.A. for bright stars relatively too faint.

(*c*) The magnitude of the motion is about 1 unit per magnitude per year, which would give a series of theoretical results, such as

Mag.		6·0.	7·5.	8·5.	9·0.	9·4.
Calculated	...	−15·0	−7·5	−2·5	0·0	+2·0
Observed	...	−13·5	−6·9	−0·6	−0·2	+2·5
O.−C.	...	+ 1·5	+0·6	+1·9	−0·2	+0·5

(The residuals would be improved a little by assuming a different rate for bright and faint stars ; but for the present we will put this aside.) This quantity 0″·03 or 0ˢ·00225 per magnitude per year is nearly double the quantity found by Sir D. Gill (see § 4) ; but it is at any rate of the same order of magnitude.

10. With these indications of the reality of the phenomenon we may proceed to combine our results to the best advantage. There seems no need to keep the results of the different zones separate, and by combining them we shall remove some of the weaknesses made apparent in Table I. The number of plates in each octant will then stand as follows :

Table V.

	0ʰ−3ʰ	−6ʰ	−9ʰ	−12ʰ	−15ʰ	−18ʰ	−21ʰ	−24ʰ
Num. early plates	12	23	29	13	29	19	33	38
,, late ,,	16	27	24	38	23	35	23	12
Mean interval in years	5·2	5·2	4·9	5·3	4·5	4·6	4·1	4·0

which should give a strong enough determination of the quantity throughout the R.A. circuit.

11. In combining the results for different zones weights have been assigned according to the number of *plates*, so as to have a uniform system of weighting for stars of different magnitudes and for the mean dates. The results are given in Table VI. The differences between early and late plates have then been divided by the mean intervals shown in Table V. so as to get the annual P.M.'s shown in Table VII., still expressed in the unit 0″·03 or 0ˢ·00225.

Table VII.

Deduced Relative Motions in each Octant.

(The unit is 0″·03 or 0ˢ·00225 per year.)

Octant.	Mag. 6·0.	Mag. 7·5.	Mag. 8·5.	Mag. 9·0.	Mag. 9·4.	Gradients (See § 24). Bright.	Mean.	Faint Stars.
h. h.								
0− 3	−6·3	−5·5	−2·1	−2·6	+0·9	−0·5	−2·07	−3·3
3− 6	+0·7	+0·4	+1·7	+0·4	+0·1	+0·2	−0·09	+1·8
6− 9	+1·4	−2·5	+0·9	+0·9	+1·9	+2·6	−0·81	−1·1
9−12	−2·1	+1·6	−0·4	+0·6	−0·1	−2·5	−0·09	−0·3
12−15	−1·1	−2·2	−0·4	−1·0	+1·3	+0·7	−0·72	−1·9
15−18	+1·5	+0·6	+0·5	+1·5	−1·9	+0·6	+0·45	+2·7
18−21	−0·9	−0·8	−1·4	+0·7	−0·3	−0·1	−0·23	−1·2
21−24	−2·9	−0·8	+0·7	−1·0	+0·3	−1·4	−0·81	+0·4
Mean	−1·21	−1·15	−0·06	−0·06	+0·28	−0·05	−0·55	−0·36

TAB

Mean Results

(The unit is

Octant of R.A.	Interval in Years.	6·0. E.	6·0. L.	6·0. L−E.	7·5. E.	7·5. L.	7·5. L−E.
h. h.							
0− 3	5·2	+74·7	+42·2	−32·5	+66·3	+37·6	−28·7
3− 6	5·2	+36·1	+39·9	+ 3·8	+18·9	+21·0	+ 2·1
6− 9	4·9	+42·4	+49·1	+ 6·7	+38·7	+26·6	−12·1
9−12	5·3	+43·2	+32·1	−11·1	+22·8	+31·2	+ 8·4
12−15	4·5	+36·6	+31·6	− 5·0	+35·8	+25·7	−10·1
15−18	4·6	+44·5	+51·3	+ 6·8	+26·2	+28·9	+ 2·7
18−21	4·1	+47·0	+41·5	− 5·5	+35·5	+32·2	− 3·3
21−24	4·0	+57·8	+46·3	−11·5	+39·8	+36·8	− 3·0

12. How far the mean quantities are accordant with the formula

$$0{\cdot}55 \times (\text{mag.} - 9{\cdot}0)$$

may be seen from the following small table.

TABLE VIII.

Mag.	Obs.	Calc.	O.−C.
6·0	−1·21	−1·65	+0·44
7·5	−1·15	−0·83	−0·32
8·5	−0·06	−0·28	+0·22
9·0	−0·06	0·00	−0·06
9·4	+0·28	+0·22	+0·06

But it seems difficult to regard the quantities O.—C. as accidental. The change is abrupt at about magnitude 8·0 rather than gradual.

13. We shall presently return to the question whether the change is abrupt or gradual; meanwhile we may note that the more careful discussion of the observations has reduced the magnitude of the relative P.M. from the value 1·00 found by the rough computation of § 9 (*c*) to the value 0·55 per magnitude per year: or in seconds of time $-0^{s}{\cdot}0013$ per magnitude per year, which is almost precisely the quantity found by Sir D. Gill (see § 4), *but of opposite sign.*

14. We will now turn to an independent piece of evidence which presented itself in the course of the work. Having occasion to refer to my earlier paper on the Cambridge magnitude equation (*Monthly Notices*, lx. p. 3), my attention was arrested by the paragraphs 11 and 13 concerning the variation of the magnitude equation with R.A. Paragraph 11 runs as follows:—

LE VI.

for all Zones.

0″·03 or 0ˢ·00225.)

8·5.			9·0.			9·4.		
E.	L.	L−E.	E.	L.	L−E.	E.	L.	L−E.
+26·0	+14·9	−11·1	−2·7	−16·1	−13·4	−31·3	−26·4	+4·9
+10·3	+19·0	+ 8·7	−5·4	− 3·3	+ 2·1	−33·3	−33·0	+0·3
+14·6	+18·8	+ 4·2	−2·4	+ 2·0	+ 4·4	−34·6	−25·2	+9·4
+17·5	+15·2	− 2·3	−9·8	− 6·4	+ 3·4	−24·6	−25·3	−0·7
+16·2	+14·5	− 1·7	−2·3	− 6·7	− 4·4	−42·0	−36·3	+5·7
+10·6	+12·7	+ 2·1	−4·1	+ 2·9	+ 7·0	−23·8	−32·3	−8·5
+21·7	+15·3	− 6·4	+0·9	+ 4·0	+ 3·1	−25·8	−27·1	−1·3
+24·3	+26·9	+ 2·6	+4·0	+ 0·1	− 3·9	−29·5	−28·3	+1·2

"Returning now to the Cambridge personality one important question is, Does it vary with the R.A.? The answer seems to be in the affirmative; but the variation is small compared with the whole amount. It is also rather exceptional in character; and as yet I can suggest no physical reason for it. The personality is rather greater for 21^h-3^h R.A. and for 12^h-15^h R.A. than for the rest of the circuit, and is greater proportionally—*i.e.* the increase is greatest for bright stars."

[In § 12 of this paper there is an error in the last line but one: *for* +0ˢ·013 *read* −0ˢ·013. The correct sign was used, but the wrong one printed.]

In § 13 of the same paper the actual figures are given as follows:—

Mag.	0^h-3^h. s	3^h-6^h. s	6^h-9^h. s	9^h-12^h. s	12^h-15^h. s	15^h-18^h. s	18^h-21^h. s	21^h-0^h. s
5·0 to 6·9	+·030	−·005	−·015	−·013	+·010	−·005	−·024	+·011
7·0 „ 7·9	+·021	−·014	+·004	−·006	+·008	−·019	−·006	+·004
8·0 „ 8·4	+·010	−·003	·000	+·001				
8·5 „ 8·9	+·006	+·004	·000	−·004				
9·0 „ 9·4	−·010	+·006	−·002	+·007				

15. Now it occurred to me that perhaps the explanation of these differences lay in a difference of date at which the *Cambridge* observations were made. In meridian observing it is a common experience to find certain parts of the catalogue "cleared off" before others; and any systematic proper motions might thus introduce apparent systematic errors. The dates of the Cambridge observations were examined in two ways.:

(A) The mean date was formed for each catalogue page (of fifty stars of all magnitudes) which contained the beginning of a new hour, *i.e.* the pages containing $0^h\ 0^m$, $1^h\ 0^m$, $2^h\ 0^m$, and so on. The mean of the *four* pages, $0^h\ 0^m$, $1^h\ 0^m$, $2^h\ 0^m$, $3^h\ 0^m$, was

considered to represent the approximate mean date of the observations in the octant $0^h - 3^h$; and so for other octants.

(B) The epochs of observation for all the bright stars (5·0 to 8·0) in each octant were set down and the mean taken.

The results are given in Table IX., wherein is also given the mean date of the Oxford plates used for the paper above quoted. It will be seen that the variations of date are chiefly in the Cambridge observations, and are small. As the discrepancy under consideration is greatest for bright stars, it seems preferable to adopt column (B) in forming the interval between the Cambridge observations and the Oxford plates during which the effects of P.M. will accumulate.

TABLE IX.

Dates of the Observations used in the Paper of 1899 *November.*

	Cambridge (A)	Cambridge (B)	Oxford	Oxford −(B)	Diff. from Mean
h h				y	
0– 3	1880·8	1880·5	1896·3	15·8	−1·3
3– 6	80·5	79·5	96·3	16·8	−0·3
6– 9	80·0	78·2	95·8	17·6	+0·5
9–12	78·5	78·4	96·3	17·9	+0·8
12–15	80·8	79·4	95·6	16·2	−0·9
15–18	80·2	79·5	96·3	16·8	−0·3
18–21	80·1	77·3	95·7	18·4	+1·3
21–24	81·1	78·0	95·2	17·2	+0·1
Mean	...	1878·8	1895·8	17·1	...

16. Now if we arrange the quantities quoted in § 14 according to the value of the interval we get the following result :—

TABLE X.

Interval (Diff. from Mean)	Octant	Observed Mag. 5·0 to 6·9	Observed Mag. 7·0 to 7·9	Calculated Mag. 5·0 to 6·9	Calculated Mag. 7·0 to 7·9
	h h	s	s	s	s
−1·3	0– 3	+·030	+·021	+·005	+·003
−0·9	12–15	+·010	+·008	+·003	+·002
−0·3	3– 6	−·005	−·014	+·001	+·001
−0·3	15–18	−·005	−·019	+·001	+·001
+0·1	21–24	+·011	+·004	·000	·000
+0·5	6– 9	−·015	+·004	−·002	−·001
+0·8	9–12	−·013	−·006	−·003	−·002
+1·3	18–21	−·024	−·006	−·005	−·003

17. There certainly seems to be some ground for the explanation of these quantities, in part at any rate, by the relative

proper motions found above. Under the heading "calculated" are given the quantities deducible on the assumption that the relative P.M. is

$0^{s}\cdot00124$ per magnitude per year.

If we add together the results for which the calculated effect is positive, and those for which it is negative, we get

	Mags. 5·0 to 6·9		Mags. 7·0 to 7·9	
Observed .	+·030	−·052	−·004	−·008
Calculated .	+·010	−·010	+·007	−·006

The total sum of positive groups is $+^{s}\cdot026$ observed and $+^{s}\cdot017$ calculated; of negative groups $-^{s}\cdot016$ observed and $-^{s}\cdot060$ calculated. The accordance is thus far from perfect.

18. A better accordance is obtained if instead of assuming the same relative P.M. throughout we take separate results for each octant. But it is unprofitable to pursue this line of inquiry further at this point, for there is a disturbing cause affecting these figures. The clock-star list in use at Cambridge was changed on 1883 January 1; and Mr. Hinks has shown (in *Monthly Notices*, lvii. p. 474) that there was a resulting apparent increase of the Cambridge R.A.'s by $+0^{s}\cdot030$.

But his discussion takes no account of the present phenomenon, and may require modification in the light of it. The inquiry should be reopened and will need an elaborate piece of work which cannot be undertaken just at present. We must be content with the qualified confirmation of our results indicated in Table X.

19. Returning then to the main conclusion of § 13—

In declination + 25° *to* + 30° *the R.A.'s of the brighter stars are decreasing relatively to the fainter* (*between the limits of magnitude* 5·0 *to* 9·5) *at the rate of* $0^{s}\cdot00124$ *per magnitude per year*—

and comparing this with the conclusion of Sir D. Gill, that

In declinations −40° *to* −52° *the R.A.'s of the brighter stars are increasing relatively to the fainter* (*between the limits of magnitude* 4·0 *and* 8·0) *at the rate of* $0^{s}\cdot0014$ *per magnitude per year*,

the question arises, whether these two facts concerning particular belts of the heavens give us any information as to the general nature of the phenomenon. It seems to me that the difference of sign proves conclusively that we are *not* in the presence of what Sir D. Gill calls "an apparent rotation of the brighter fixed stars as a whole with respect to fainter stars as a whole." If there is such a rotation about any axis whatever we may resolve the minute effects observed hitherto into effects due to the rotations about two axes, one parallel to the axis of the Earth and the other perpendicular to it. The latter will

produce zero effect in R.A. for the mean of a zone of stars of the same declination (assuming the system of equal weighting adopted by Sir D. Gill and also in the present paper); while the former would produce a rotational effect which should have *the same sign for all zones*. The direct contradiction of sign in the northern and southern hemispheres seems to put this idea of a general rotation out of court.

20. Before proceeding to make any suggestion in place of it, let us consider again what is involved in the system of equal weighting in R.A. adopted by Sir D. Gill. He adopted it to eliminate the effect of the Sun's motion through space. I may perhaps quote a few words from a letter of his to me (dated 1902 Sept. 10) where he puts his point clearly.

"The parallactic motion due to the Sun's motion through space is:

$$\mu_\alpha = + V\varpi \cos D \sec \delta \sin (\alpha - A)$$
$$\mu_\delta = - V\varpi \{\cos \delta \sin D - \sin \delta \cos D \cos (\alpha - A)\}$$

where V is the Sun's velocity expressed in radii of the Earth's orbit, A and D the R.A. and Decl. of the point in the heavens towards which the Sun is moving, and ϖ the annual parallax of a star whose R.A. and Decl. are α and δ.

"Now μ_α disappears in the mean proper motion of stars of the same Decl. Symmetrically distributed in R.A. μ_δ does not; hence the comparative simplicity of discussing R.A. only. Of course the complete discussion must involve the discussion of the declinations, but the result can only be derived by successive approximations."

21. Now, it is only true that "μ_α disappears in the mean proper motion of stars of the same Decl. symmetrically distributed in R.A." *if ϖ remains constant*; but if ϖ varies the mean will not generally be zero. Sir David Gill has selected stars of constant *magnitude*, but does it follow that they have a constant *parallax*? We have very little information on the point, and what we have is rather against this conclusion than for it. Not to speak of individual or exceptional cases, we have learnt, from the work on the "Cape Photographic Durchmusterung," that there is a systematic difference between the visual and photographic magnitudes of stars, depending on their galactic latitude. Is it the visual or the photographic magnitude which indicates the parallax? It is true the difference is small compared with either; but this is only one piece of evidence of *structure* in the universe, and directly the idea of structure is introduced we must admit that the parallax of a star will depend not only on its magnitude but on its *position*. If ϖ varies with δ and α the mean value of μ_α is no longer zero on the system of equal weights.

22. It seems possible, then, that Sir David Gill has indicated, not a general rotation in the universe, but a method of gauging its detailed structure; a method of elementary sim-

plicity and of the gravest importance. We must set to work to determine the gradient of relative proper motions as we pass from bright to faint stars in every quarter of the heavens, and study the results as they accumulate. In particular it would seem almost imperative that, as soon as possible after the Astrographic Catalogue, or any portion of it, is completed, it should be recommenced with a view to the determination of these proper motions.

23. But although our present information is scanty, it is, perhaps, not too early to anticipate a possible reason for the difference of sign found in the N. and S. hemispheres. The apex of the Sun's motion is at 18^h R.A. The Milky Way rises highest into the northern hemisphere about 0^h, where the effect of the parallactic motion is in the direction of increasing R.A. ; while stars about 12^h, with decreasing R.A., are at nearly the limit of distance from the galaxy. These conditions are, of course, inverted in the southern hemisphere.

24. Let us consider in detail whether this may afford the clue to the cause of the phenomena under consideration. Returning to Table VII. the last three columns give three "gradients" formed as follows : Subtracting from the mean of the results for magnitudes 6·0 and 7·5 the mean of the three results for 8·5, 9·0, and 9·4, and dividing the difference by 2·2 (the difference of the mean magnitudes) we get the mean relative P.M. for one magnitude, which is called the mean gradient. But as there seems some reason to suppose that the gradient is not uniform two other columns have been formed : that for "Bright" stars by comparing the results for 6·0 and 7·5 and dividing by 1·5 ; and that for "Faint" stars by comparing 8·5 and 9·4 and dividing by 0·9. The accidental errors of these columns are of course larger than that for the mean.

25. Now if we are to explain these relative P.M.'s in terms of the Sun's motion in space, we must consider the parallactic factors for the eight octants. In the expression given above

$$\mu_\alpha = V\varpi \cos D \sec \delta \sin (\alpha - A)$$

we assume

$V \cos D$ constant for the present

[It is of course possible that $V \cos D$, which is the motion of the Sun *relative to the stars*, may vary for different regions of the sky ; and in fact some general suppositions of this kind have come under consideration in the course of the work, but were discarded later.]

and $\sec \delta$ is constant for our zone

Hence we need only consider the factor

$$\varpi \sin (\alpha - A)$$

If we divide the "gradient" by $\sin (\alpha - A)$ we get quantities

proportional to ϖ, which now represents the *difference of parallax per magnitude*. This division is performed in Table XI., and the galactic latitude of the group is added for comparison.

TABLE XI.

Octant. h. h.	Sin (α−A).	Differences of ϖ per mag. 6·0−7·5.	Mean.	8·0−9·4.	Galactic Latitude. °
0−3	+·9	−0·6	−2·3	−3·7	−34
3−6	+·4	+0·5	−0·2	+4·5	−13
6−9	−·4	−6·5	+2·0	+2·8	+22
9−12	−·9	+2·8	+0·1	+0·3	+61
12−15	−·9	−0·8	+0·8	+2·1	+80
15−18	−·4	−1·5	−1·1	−6·8	+40
18−21	+·4	−0·2	−0·6	−3·0	+ 2
21−24	+·9	−1·6	−0·9	+0·4	−25

26. Looking now first at the column "Mean" (the others being affected by larger accidental errors), let us arrange the results in order of galactic latitude (taking no account of sign in this latitude).

Gal. Lat.	+2°	−13°	+22°	−25°	−34°	+40°	+61°	+80°
Mean	−0·6	−0·2	+2·0	−0·9	−2·3	−1·1	+0·1	+0·8

But for the positive sign at +22° these would fall into fairly regular sequence, all the quantities near the galaxy being negative and those near its poles positive; unless the + sign at +22° is an indication (allowing for accidental errors) of a return to a positive sign close to the galaxy.

27. The physical meaning of these figures would be, that within 24° of the Milky Way, and also near its poles, a bright star is nearer us on the average than a faint; but that for intermediate galactic latitudes (25°–50° say), and for a certain range of magnitudes, the *faint stars are actually nearer us than the bright*. And we have now to consider how this could be explained.

28. First consider a number of stars of the same intrinsic brightness (for brevity say the same *size*) scattered uniformly through space. When regarded from any view-point the apparent brightness of any of them varies as $1/(\text{dist.})^2$; or if 2·512 be denoted by a^2, the magnitude by m, and the distance by d

$$a - 2m = \text{brightness} = C^2 d^{-2}$$
$$\text{or } d = Ca^m$$

where C is a constant.

The total number of stars within a distance d varies as d^3, or

a^{3m}, and the number between magnitudes m and $m+1$ thus varies as $a^{3m+3}-a^{3m}$), which itself varies as a^{3m}. Hence we have for stars of magnitude m

$$\text{Parallax} = Aa^{-m}$$
$$\text{Number} = Ba^{3m}$$

where A and B are constants depending on the number of stars per unit volume and the intrinsic brightness of each.

29. Secondly, suppose we have two such systems superposed, the constants for one being A_1 B_1, for the other A_2 and B_2. Then we have for stars of magnitude m

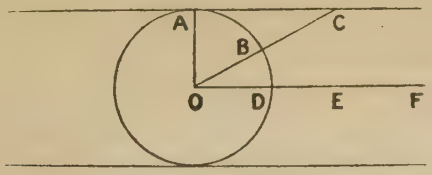
B_1a^{3m} stars of parallax A_1a^{-m}
B_2a^{3m} „ „ A_2a^{-m}

So that the *mean* parallax for magnitude m is now

$$\frac{B_1A_1+B_2A_2}{B_1+B_2}a^{-m} = A_3a^{-m}$$

i.e. it follows the same law of decrease with magnitude as before only with a different constant A_3 instead of A_1 or A_2, and intermediate between them, since B_1 and B_2 are both positive.

30. Now imagine two systems of stars to be superposed, one a set of small (*i.e.* intrinsically faint) stars uniformly scattered round the Sun in all directions as represented by the circle ABD, the Sun being at O.



Let the central plane of the galaxy be in the direction ODEF, and suppose the galaxy to be a superposed system of large stars (*i.e.* intrinsically brighter than those of the "solar cluster," as we may call the first set perhaps).

Consider the relation between brightness and parallax along three radii, OA, OBC, ODE.

Along OA we have both systems freely mixed, and the relation between magnitude and parallax will follow the usual law.

$$\text{Mean parallax} = A_3a^{-m}$$

where A_3 is, as shown above, intermediate between A_1 and A_2 ($A_1 > A_2$).

Along OBC, however, the stars are only mixed as far as B; and from B to C we have some *large stars* which are thus

reckoned as near us. In fact there is a discontinuity in the law connecting magnitude and parallax. We start with a series

$$A_3 \quad A_3a^{-1} \quad A_3a^{-2} \quad A_3a^{-3} \ldots A_3a^{-r}$$

and we must ultimately change to the series

$$A_2a^{-(r+1)}, \quad A_2a^{-(r+2)}, \text{ \&c.}$$

where A_2 is less than A_3.

So that though the early terms of the series decrease, and the later terms will ultimately decrease, we have near a certain magnitude r an *increase*, viz.

$$A_2a^{-(r+1)} > A_3a^{-r}$$

which will be the case provided

$$A_2 > aA_3, \text{ i.e.} > 2{\cdot}512\ A_3.$$

An abrupt change at a definite magnitude is of course only taken for illustration. The discontinuity will no doubt be spread over several magnitudes ; but it is clear that we may in this way get, for a limited range of magnitudes, an *increase* of parallax with decreasing brightness instead of the usual *decrease*.

31. Finally consider the radius ODEF. To make the explanation accord with what has been assumed above, we must show cause why there should be a return to the normal state of things in directions near the galaxy itself. Now the existence of the anomaly depends upon the inequality

$$A_2 > aA_3$$

and from above we have

$$A_3 = \frac{B_1A_1 + B_2A_2}{B_1 + B_2}$$

B_1 and B_2 being proportional to the numbers of stars of each class. As we approach the galaxy we include more stars of the galactic type, and hence we may assume that B_2 increases ; so that A_3 approaches nearer A_2, and the inequality no longer holds.

32. This, then, is the rough suggestion for the phenomena observed. It seems worth putting forward as a "working hypothesis," which can be at once tested in several ways, and especially the proper motion in *declination* must be examined for the same plates as have been examined above in R.A.

But this must be deferred to a future paper. Meanwhile the results obtained are so interesting that it seems desirable to publish them at once ; and I put this hypothesis along with them, not as fully established, but as one with which it is desirable to compare future results, until it is definitely contradicted by any of them. The former hypothesis of Sir David Gill, of a general rotation of the bright stars with respect to faint stars, turns out

(if the results above given may be accepted) not to be well founded; but I would be among the first to be grateful to him for enunciating it, since it was the means of drawing my attention at once to a line of work which seems likely to bear fruitful results.

And I will venture to add here another word or two of a personal kind. In No. 517 of the *Astronomical Journal* Professor Lewis Boss called attention to the fact that in determining the Cambridge magnitude equation I had treated proper motions as accidental errors, which would disappear in the mean of a number of stars. "Unless this statement is surrounded by several qualifications," wrote Professor Boss, "it is by no means correct," and he went on to specify the qualifications, among which considerations of the Sun's parallactic motion were prominent. Some misunderstandings of what had actually been done in the Oxford work, and, on my part, of what Professor Boss really meant, gave rise to a discussion which turned out to be irrelevant to the real issue (*Astronomical Journal*, Nos. 519, 521, 523). It has been, I hope, satisfactorily closed. But now that I properly understand the real meaning of Professor Boss's remarks with regard to the parallactic motion, it gives me peculiar pleasure to be among the first to confirm their soundness and value in a new way.

A Note relating to the Preservation of Negatives.
By F. A. Bellamy.

Some weeks ago I had occasion to examine a negative of a comet taken in 1899, and upon withdrawing it from its envelope, similar to those used at the University Observatory, Oxford, for storing plates taken for the Astrographic Catalogue, it was immediately noticed by Mr. H. C. Plummer and myself that a representation or impression of the description of the negative written outside the thick envelope had been conveyed to the gelatine film, and almost every letter and figure—though blurred in character, much as a heavily written word would appear on blotting-paper immediately used—could be read *from the plate*. It should be noted that no mark is visible on the *inside* of the envelope to show that the ink had soaked through.

I have since examined a large number of our plates, and I have, I am pleased to state, found very few cases; I may say in general terms that no plate which apparently had a short development and those taken on dark nights—in fact, those that had a bright, clear appearance, and upon which the stars and réseau lines stood in relief, as in the carbon process—showed any sign of this transmitted writing; but the plates that did show it

were in every case, I believe, rather dense in character, either by a light sky, long development, by light getting to the plate before development, or by the old age of the plate before being exposed, especially those packed with sheets of paper between the plates. The ink used was always Stephen's Blue-black or Draper's Dichroic, and was written usually, if not always, on the envelope before the plate was put in. Some words as to when the plate was measured, or other notes, are added from time to time.

In view of the large quantity of plates that are being used in modern astronomy and stored in envelopes for future use it seems desirable to call astronomers' (and others') attention to this small matter, and to use every precaution to prevent any deterioration of negatives. Damp and an undue amount of sunlight are the greatest enemies to the gelatine film of a negative, but certainly by neither of these causes have our plates suffered at Oxford.

May the cause of this marking, not by bleaching, but by staining, be due to a strong acid or chemical used in the manufacture of the ink, or perhaps that combining with the chloride of lime, from which very little modern paper seems free?

For ordinary negatives the best precaution would undoubtedly be to varnish them, but for negatives required for measurement it is not to be recommended, as there are not many who could frequently flow the varnish over the plate without getting a ridge or overlap of varnish, either of which would tend to distort the image of a star or réseau line.

Nearly twenty years ago (1884 or 1885), some time after I first used the gelatine dry plate instead of the wet collodion process, I well remember spoiling some ordinary negatives by merely packing them for a short time with pieces of printed paper between them, and I could have read most of the printing impressed upon them. I believe I still possess some of these plates. Things of this kind one does naturally by inexperience, especially with a new article—as the commercial dry plate then was—and I have not been entrapped to treat negatives in that way since; but what I have made the subject of this short note is, I believe, new, and one that also requires attention being paid to it.

London: 1902 *Dec.* 12.

Note on Binding together Réseaux and Plates.

By J. A. Hardcastle.

It seems probable that réseaux will have to be laid on to photographic plates constantly in the near future for two sufficient reasons: (1) A réseau much facilitates measuring a

plate ; (2) a very large number of plates, *e.g.* all those hitherto taken in America, have no réseau impressed on them before development. In view of this fact it cannot be superfluous to put on record a piece of recent experience in connection with binding réseaux on to negatives.

It is not an easy matter to bind a plate bearing a réseau to a negative with complete rigidity, and it is on this point that a word of caution seems necessary. No binding, however secure in appearance, should be subjected to strain. In the particular instance on which this note is based it was found that, whether from damp or from other cause, the grip by which the plate is held firm in the measuring machine caused one plate to slip over the other. It occurred in the course of Mr. Saunder's work in the measurement of lunar photographs (see *Monthly Notices*, vol. lx., p. 174, and vol. lxii., p. 41). The photographs we have been measuring were taken at Paris and have no réseau on them. The size of the Moon on these plates is about $6\frac{1}{2}$ inches, while the réseau was less than 6 inches square, consisting in fact of 31 lines in each direction 5 mm. apart. In the plate in question the phase was but little over half-moon, and so it was possible to cover the whole visible moon with the réseau by placing the terminator diagonally. The corners of the negative were trimmed off, but the plates were eventually bound together with the edge of one projecting slightly on one side and the edge of the other projecting slightly on the opposite side. The risk of displacement would, of course, have been considerably diminished had the same plate projected on all four sides, but it was desired to reproduce previous measurements and the advantages seemed to outweigh the risks. The binding was extremely strong, but it became evident eventually that a translation amounting to ·075 mm. (·003 in.) and a rotation of 52″ had taken place.

Although the larger part of this shift was proved to have taken place on one particular day in September, during which the plate was not taken from the measuring machine, the remainder of the displacement (about ·03 mm.) occurred apparently more or less gradually in August.

The only possible method of detecting such a gradual displacement is the daily record of the positions of four fiducial marks, one at each corner of the negative. Such marks may be made on the film of the negative with a needle-point before binding, and should be read at the beginning and end of each day's work.

For the binding seccotine would be preferable to ordinary gum, and a touch of shellac might be used between the films at each corner.

Another difficulty in using réseaux bound on to negatives arises from the fact that the surfaces of the glass are not plane, and accordingly contact is not universal over the whole negative. Besides the obvious risk of parallactic displacement of a réseau-line relatively to the negative there has been further found a

change of position of réseau-lines when the direction of the source of illumination changes. It has accordingly been found necessary to use an adjustable clamp, to press the two surfaces into contact in the neighbourhood where measurements are being taken. The use of plate glass would obviate the necessity of this precaution ; but the fact remains that it has not been used, nor have réseaux been impressed on the negatives, and it is accordingly a matter of great interest that experience in dealing with the plates actually in existence should be recorded.

Photographic and Visual Magnitudes of α Orionis.

By W. H. Robinson.

(*Communicated by A. A. Rambaut, M.A., Sc.D., F.R.S., Radcliffe Observer.*)

Since Mr. Packer's announcement concerning the increase of brightness of *α Orionis* several photographs of the region of the sky including this star have been secured, the half-plate camera used being that employed last year in the determination of the photographic magnitude of *Nova Persei*. The results of the latter investigation were published in the *Monthly Notices* of the R.A.S., vol. lxii., Nos. 3 and 6. In No. 3 the writer drew attention incidentally to the chemically active quality of the light of the new star on 1901 March 9, and contrasted with it the non-actinic character of the light of *α Orionis*, which at the time was visually similar to it in colour. This photograph has now become additionally useful, being included with the recent photographs in the following discussion.

In the present paper the methods of measurement of images and reduction of results for *α Orionis* are precisely similar to those adopted for *Nova Persei*.

Nine comparison stars have been selected in determining the scale of brightness. The names of these, with their tabular (Harvard) magnitudes and mean measured photographic brightness, are as follows :—

Name of Star. *Orionis.*	Tabular Magnitude.	Scaled Photographic Brightness (Means).	Name of Star. *Orionis.*	Tabular Magnitude.	Scaled Photographic Brightness (Means).
γ	1·75	20·0	λ	3·5	45·8
ε	1·75	28·2	σ	3·75	53·2
ζ	1·9	28·4	A	4·4	56·6
δ	2·5	31·1	ϕ^1	4·4	58·8
η	3·45	50·3			

Plotting the above values on square-ruled paper, and drawing

a smooth curve through them, the magnitude equivalents for arbitrary scale were found to be:

Scale.	Magnitude Equivalent.	Scale.	Magnitude Equivalent.
20	1·52	45	3·38
25	1·87	50	3·76
30	2·26	55	4·13
35	2·64	60	4·50
40	3·01		

The equivalents were then adopted for forming the photographic magnitudes of *α Orionis*, which, together with the visual magnitudes, are exhibited in the following table. The visual magnitudes are only approximate, since they depend upon comparison with two stars only, viz. *Capella* and *Rigel*, which differ greatly from *α Orionis* in colour and position. Their widely differing zenith distances rendered necessary the application of corrections for atmospheric absorption, the formula adopted being

$$A = 0{\cdot}25 \text{ (sec. } Z - 1).$$

The small differential residuals of these corrections have been allowed for in column 5.

Ref. No.	G.M.T.	Sealed Readings.	Photographic Magnitudes.	Visual Magnitudes. *Corrected* for Atmospheric Absorption.	Visual Magnitudes. *Uncorrected* for Atmospheric Absorption.
	1901. h				
1	Mar. 9 9½	38·8	2·92*	(0·91)†	(0·91)†
	1902. h				
2	Oct. 22 12½	35·6	2·68	...	...
3	Nov. 8 11−	36·9	2·78	0·23	0·25
4	8 11+	37·4	2·82	0·23	0·25
5	12 12	38·3	2·88	0·27	0·25
6	28 11	...	...	0·27	0·25
7	Dec. 1 11	...	...	0·27	0·25
8	3 10	...	...	0·29	0·29
9	4 11	...	...	0·29	0·29
10	6 11	38·6	2·91	0·29	0·29.

Remarks.—1. Photographed on same plate with *Nova Persei.* The values in cols. 5 and 6 marked thus ( )† are taken from Harvard Photometry. 2. Light clouds passing at times; moonlight. 3, 4, 5. To the naked eye *α Orionis* is certainly brighter than *Rigel* and distinctly fainter than *Capella.* 8. *α Orionis* is not so bright to-night to the naked eye; it is nearer *Rigel* than *Capella* in magnitude. 9, 10. *α Orionis* between *Capella* and *Rigel* in brightness, nearer *Rigel.*

**Erratum.*—P. 199 of vol. lxii., *α Orionis.* Photographic magnitude. *For* 3·20 *read* 2·92, the latter being the definitive value, the former only a provisional one.

During the period 1902 Oct.–Dec. the observers at Oxford have several times noted an unusually crystalline image of *α Orionis*. The star *Capella* has generally been observed by the writer to be about one magnitude brighter than *Rigel*. Allowing for the effect of atmospheric absorption, a difference exists of about 0·6 or 0·7, which is sensibly greater than that given in the Harvard Photometry, viz. 0·14. Within small limits these two comparison stars are probably variable, as suggested by W. Struve and Argelander respectively, and by others.

It will be seen in the preceding table that between 1901 March 9 and 1902 October 22 the photographic magnitude of *α Orionis* had increased, but only slightly. Since October 22, however, a gradual decline appears to have set in. The evidence afforded by the visual estimates, and by the remarks appended to them, also confirms not only the brightening between the two first dates, but the slight decrease which appears to have taken place subsequently.

Radcliffe Observatory, Oxford:
1902 Dec. 10.

Cape Double Star Results, 1902. By R. T. A. Innes.

(*Communicated by Sir David Gill, K.C.B., F.R.S., H.M. Astronomer.*)

The winter was a very wet one, so that very few nights were available for double-star work. Through leave of absence, observations ceased early in August. All the measures were made with the Repsold micrometer on the 18-inch refractor. In the cases of a few newly discovered pairs estimates only have been secured: these were generally made at the 7-inch refractor.

A few measures previously omitted are included.

The measures of α Centauri will be found on p. 81.

The screw-value used in 1902 is 17″·600.

The colour scale used and the general arrangement of the results are as in 1901. See *Monthly Notices*, vol. lxii. pp. 470–484.

Incidentally it was found that the star G.P.Z. 7641, mag. 8·7, occupies the centre of a round nebula of about 3′ diameter, and it is therefore a nebulous star. Its position is:

	h	m	s	°	′
1860	11	5	32	−75	51·2
1875	11	6	1	−75	56·3
1900	11	6	49	−76	4·4

Mag. in the C.P.D. = 8·6.

The nebula *h* 3413 = N.G.C. 4976 is identical with C.P.D. −48°, No. 5305, (1860) 13h 0m 38s—48° 45′·4.

Star.	Mag.	1900. R.A.	1900. S. Dec.	1902·±	Pos. Angle.	Dist.	Diff. of Mags.	Colours A.B.	No of Nights.	Remarks.
		h m	° ′		°					
Innes 27	... 7·3	1 12	69 21	15	208·0	0·96	0·6	...	1	
κ Toucani	... 4·9	1 12	69 24	15	352·8	5·00	...	3, —	1	1
Cape 27	... 7·9	2 33	88 50	...	204·9	...	...	...	2	2
Innes 386	... 7·2	2 37	59 59	15	143·5	0·3 ±	0·2	0, 0	1	
Lac. 912	... 6·7	2 49	41 48	15	295 ±	15 ±	6·8	...	1	3
Innes 150	... 8·2	3 16	63 26	14	358·0	3·93	2·5	...	1	22
C.P.D. 357	... 9·0	3 42	40 29	14	211·4	3·78	1·1	...	1	4
h 3641 ...	... 5·3	4 13	62 27	15	253·8	8·43	4·0	4, *b*	2	
C.Z. 4h727	... 7·8	4 23	24 41	2	330 ±	0·7 ±	0·5	...	1	5
κ Pictoris	... 6·4	5 21	56 15	0	60 ±	0·5 ±	0·1	...	1	6
Innes 349	... 7·0	6 11	29 34	30	45·1	5·90	...	...	1	
Cape 23	... 8·5	6 12	49 5	30	63·5	5·32	...	4, *b*	1	
h 3845 ...	... 7·0	6 13	22 40	30	20·1	35·1	...	2, —	1	
G.P.Z. 3956	... 9·4	6 19	73 26	1	260 ±	2 ±	1·0	...	1	7
β 754 ...	... 7·0	6 31	33 56	30	33·3	1·09	0·1	2, 2	1	
Dunlop 31	... 5·0	6 36	48 8	30	319·4	12·9	...	4, *b*	1	
Innes 65	... 6·3	6 54	35 23	30	207·6	...	...	...	1	8
„ 183	... 7·5	6 57	25 30	16	147·0	3·35	2·4	1, 5	2	
„ 184	... 8·0	7 8	60 25	21	179·1	poor	...	...	1	
Hargrave 9	... 7·5	7 8	56 12	01	219·9	1·42	1·0	...	1	
Lalande	... 4·9	7 12	23 8	36	60·6	27·3	...	...	2	9
Cordoba [71]	7·7	7 31	66 58	11	192·3	3·66	...	4, *b*	2	
Innes 285	... 8·8	7 35	48 27	35	138·5	1·04	1·0	...	1	
d_2 Puppis	... 5·9	7 36	37 55	35	150·7	1·59	...	...	1	10
Innes 353	... 7·4	7 36	43 3	32	214·5	0·91	0·4	0, 0	2	
„ 185	... 9·5	7 37	29 53	32	195·7	1·81	0·6	...	2	
„ 354	... 7·5	7 39	42 20	35	124·9	1·14	1·6	...	1	
ζ Volantis	... 3·8	7 43	72 22	01	116·0	17·1	...	...	1	
Innes 161	... 5·3	7 44	38 16	35	83·6	10·5	4·0	...	1	
Cape 20	... 8·5	7 45	44 18	35	87·2	3·08	1·2	...	1	
b Puppis	.... 4·7	7 49	38 36	35	nil	...	...	...	1	36
Innes 163	... 8·2	7 57	40 18	35	119·4	0·78	2·5	...	1	
„ 187	... 9·2	7 58	34 12	26	12·9	3·53	2·7	...	2	
„ 188	... 9·3	7 59	34 17	08	339·1	2·92	0·3	0, 0	2	
„ 164	... 7·5	8 3	39 49	27	77·2	0·64	1·0	3, 3	1	

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Innes 191	8·7	8 5	41 37	35	199·8	0·99	0·7	...	1	
„ 166 A-B	9·0	8 11	52 4	16	239·9	2·16	2·0	...	1	
„ „ A-C				„	277·2	8·40	3·0	...	1	
Corboba (76)	8·2	8 13	34 33	26	148·2	2·02	0·5	...	1	11
Innes 9	6·8	8 16	73 30	36	308·9	0·78	0·1	2, 2	1	12
„ 194	9·0	8 17	59 53	36	132·7	1·33	1·0	3, *b*	1	
„ 393	6·5	8 19	26 2	26	221·8	3·26	7·5	3, —	2	
B Velorum	4·8	8 19	48 10	36	141·4	0·89	1·5	...	1	
Brisb. 2035	7·5	8 24	40 55	26	107·1	6·15	2·5	...	2	
Innes 394	8·0	8 26	38 16	36	189·4	0·70	0·7	...	1	
„ 313	7·2	8 27	41 11	36	216·2	3·79	2·0	4, B	1	
„ 168	6·9	8 27	44 24	36	79·0	3·34	3·5	...	2	
h 4106	7·8	8 28	36 21	26	146·0	6·30	2·0	3·5, *b*	2	13
h 4107	6·6	8 28	38 44	26	328·9	4·36	...	2, *b*	2	
Innes 11	6·5	9 12	45 8	27	269·9	0·94	1·5	2, 2	1	14
„ 12	5·4	9 18	74 28	25	259·4	0·3 ±	...	...	1	15
ψ Argûs	3·5	9 27	40 2	21	338·8	0·48	...	...	4–1	16
C.Z. 9h 2351	8·8	9 30	43 52	26	169·7	4·46	0·1	...	2	17
Innes 350	8·0	9 34	67 46	18	179·2	1·68	...	...	2	
λ 115	5·5	9 34	53 13	21	168·4	0·78	...	3, 3	3	
Innes 360	8·9	9 34	66 50	12	184·4	5·16	...	2, *b*	1	
„ 202	7·0	9 35	39 10	31	175·3	1·09	2·0	2, *b*	1	
„ 203	8·2	9 36	62 6	25	314·3	0·3 ±	...	...	1	18
„ 320	8·6	9 36	66 15	12	47·9	1·09	...	...	1	
Rumker 12	6·7	9 53	68 43	36	213·0	9·46	1·5	...	1	
φ Argûs	3·7	9 53	54 6	40	9·0	37·3	...	...	1	
Innes 322	9·0	9 55	62 5	40	66·2	1·87	1·0	...	1	
„ 290	9·2	9 59	59 36	4[illegible]	284·3	1·14	1·0	...	1	19
C.P.D. 1699	9·6	9 59	59 28	42	92·5	5·26	0·1	...	2	19
„ 1718	9·2	9 59	59 31	42	274·2	2·27	1·5	...	2	19
Innes 291	7·2	9 59	70 15	38	321·3	1·07	2·5	2, *b*	2	
„ 292	7·3	10 0	27 54	40	210·4	0·66	0·3	3, —	1	
„ 293	6·9	10 1	27 43	40	327·5	0·54	...	...	1	
„ 173	5·2	10 2	46 53	31	53·7	0·57	2·8	3, —	1	
„ 13 A–B	6·4	10 7	68 12	47	326·3	0·75	0·1	3, 3	2	
„ AB–C				50	40·3	25·8	...	...	1	20
„ 361	8·5	10 9	46 59	30	135·4	4·77	2·0	3, —	2	

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		h m	° ′	°	″				
Russell 139...	7·2	10 12	66 47	45 333·5	2·12	1·8	4, *b*	1	
C.Z. 10h 889	8·7	10 13	41 1	38 338·8	2·69	0·7	*y*, *b*	2	21
Innes 206 ...	8·5	10 14	22 40	26 328·0	1·01	...	...	2	
„ 207 ...	8·5	10 14	32 43	43 322·4	2·27	0·3	...	2	
Russell 141...	7·7	10 17	66 40	47 45·8	1·93	1·2	*y*, *b*	2	
Innes 208 A−B	7·5	10 20	43 44	47 26·5	0·78	1·1	...	2	
„ „ AB−C				50 22·0	24·2	6·5	...	1	
„ 209 A−B	7·5	10 20	38 4	47 137·0	0·77	0·1	2, 2	2	
„ „ AB−C				50 126±	20±	7·5	...	1	
„ 210 ...	7·7	10 23	38 12	47 236·1	0·95	2·5	...	2	22
„ 73 ...	7·2	10 25	48 29	14 221·4	5·31	...	2, *b*	2	23
„ 174 ...	8·4	10 28	61 4	... 50·3	1·00	2·0	...	2	24
„ „ ...				46 46·0	0·98	1·5	...	2	
„ 32 ...	9·0	10 28	61 17	45 343·9	4·98	2·0	...	1	
Cordoba (24)	7·4	10 31	57 10	28 238·4	5·17	2·3	4·5, B	2	25
Innes 74 ...	8·5	10 32	63 37	28 231·7	2·96	1·4	−, *r*	2	
„ 175 ...	7·7	10 32	47 20	28 156·5	1·93	3·2	...	2	
C.Z. 10h, 2403 A−B	9·0	10 34	64 51	28 14·3	0·59	0·1	...	2	26
„ AB−C				28 6·1	5·07	0·2	...	2	
Innes 397 ...	8·7	10 40	36 21	25 352·1	1·24	1·0	...	1	
„ 398 ...	8·8	10 42	56 48	34 235·2	4·52	...	...	2	
δ_1 Chameleontis ...	5·5	10 44	79 56	28 60·0	0·69	0·3	4, 4	2	
h 4373 ...	8·9	10 44	40 55	47 344·5	11·0	0·5	...	1	
Bris. 3273 ...	8·5	10 49	62 33	38 203·3	2·33	0 2	4, 4	2	27
Russell 164...	7·0	10 55	60 47	44 81·7	3·78	3·5	3, −	1	
Innes 212 ...	7·0	10 58	81 1	31 151·3	0·73	...	...	1	
C. G. A. 166 (*x* Carin.)...	9·7	11 3	58 10	34 221·3	2·85	2·0	...	2	28
Innes 213 ...	8·0	11 6	32 1	36 125·9	0·82	2·5	...	1	
h 4421 ...	6·8	11 11	47 22	40 67·4	23·0	3·3	...	2	29
C.P.D. 2224	9·6	11 17	61 29	48 34·5	1·11	0·5	...	1	30
Innes 76 ...	9·5	11 22	30 11	33 50·5	7·06	0·5	...	1	
Lac. 4834 ...	7·7	11 33	60 56	51 117·7	1·32	2·7	...	2	31
„ 4829 A−B	7·2	11 34	62 49	54 94·1	0·53	0·0	3, 3	3	31*a*
„ „AB−C				54 359·6	1·66	3·0	...	3	
„ „AB−D				56 323·2	9·48	5·0	...	2	

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		h m	° ′		°	″				
h 4460	... 7·5	11 34	57 11	41	176·3	8·58	1·3	...	2	
Howe 17	... 6·9	11 49	37 12	16	277·7	2·05	...	...	1	
Washburn 115	8·3	11 59	57 11	44	244·8	1·84	1·5	...	2	
h 4498	... 5·9	12 1	65 9	44	61·6	8·75	...	3, B	2	
Jacob [8]	... 6·4	12 5	34 9	53	19·8	3·15	2·0	...	1	32
Lac. 5049	... 7·0	12 6	44 52	36	170·8	2·34	2·8	4, B	2	33
h 4507	... 8·1	12 8	44 20	45	223·4	16·3	...	4½, B	2	
Innes 81	... 9·0	12 10	29 13	36	344·0	2·71	...	...	1	34
λ 154	... 5·1	12 21	50 54	55	284·8	22·5	8·4	3, —	1	35
Innes 35	... 8·5	12 21	76 7	31	315·3	2·37	...	...	1	
Cape 12	... 7·0	12 23	61 12	39	260·1	2·09	0·8	4, 2	2	
Lac. [5169]	... 6·2	12 23	55 51	55	290·5	49·2	5·8	4, —	1	
Innes 36	... 7·7	12 23	61 19	40	325·3	21·8	4·8	...	2	
„ 218	... 7·3	12 24	37 25	28	234·5	2·34	2·5	3, *b*	2	
„ 309	... 7·7	12 26	77 39	31	nil	...	...	...	1	
„ 82	... 7·9	12 26	40 57	28	353·7	0·80	1·0	...	2	37
„ 219	... 8·5	12 26	55 34	26	50·0	1·64	1·0	...	2	38
„ 296	... 6·7	12 33	74 49	42	274·3	1·84	2·3	2, *b*	2	39
γ Centauri A—B	2·4	12 36	48 25	36	355·7	1·54	...	...	2	
„ AB—C				36	117·5	39·5	11·6	...	2	40
Innes 324	... 8·5	12 37	83 7	33	279·2	3·89	0·8	...	2	
h 4544	... 9·0	12 39	78 55	44	298·8	3·05	2·5	3, B	2	
β Muscæ	... 3·3	12 40	67 37	39	344·5	1·16	0·1	3, 3	2	
β Crucis	... 1·7	12 42	59 8	43	322·3	44·4	...	...	2	
ι Octantis	... 6·3	12 44	84 35	55	nil	...	...	...	1	
Lac. 5299	... 6·7	12 47	53 17	55	211·8	7·01	4·0	4, *b*	1	41
Innes 83	... 7·0	12 51	47 9	37	277·2	0·54	0·1	3, 3	2	42
„ 363	... 8·5	12 55	67 19	33	194·2	2·62	1·3	...	2	22
C.Z. 12h 3298	8·5	12 57	59 4	44	356·0	3·56	0·1	...	2	
λ 168	... 7·5	12 58	38 26	35	nil	...	...	...	1	
Ref. Cat. 14 A—B	4·7	13 6	59 23	53	345·5	1·55	3·2	...	2	43
C.P.D. 6088	8·3	13 7	40 13	44	236·2	2·26	0·5	...	2	44
Lac. 5456	... 6·8	13 11	67 58	50	214·0	0·47	0·7	1, 1	4	41
C.Z. 13h 629	8·7	13 12	40 1	53	320·3	1·05	1·5	0, 0	2	45
Innes 220	... 7·7	13 19	34 7	44	6·6	0·63	1·5	3, 3	2	
Cape 32	... 8·4	13 20	52 46	53	263·1	4·08	1·0	...	1	

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Innes 298 ...	7·2	13 25	68 43	36	205·3	0·75	1·7	4, 4	2	
„ 365 ...	6·5	13 30	61 11	46	214·3	0·39	0·2	3·3, 3·3	3	46
„ 221 ...	7·2	13 31	31 54	54	167·7	0·56	1·5	...	2	
λ 183 ...	8·0	13 32	31 51	53	Looks single		...	...	1	
Innes 401 ...	8·5	13 49	42 5	29	232·0	0·41	0·1	3, 3	2—1	
„ 225 ...	7·2	13 54	62 28	26	299·8	...	...	...	1	
„ 325 A—C	8·7	14 11	68 10	55	43·9	44·8	...	...	1	47
„ „ B—C				55	222·5	7·98	...	...	1	
Russell 244...	6·5	14 16	47 52	40	123·4	4·01	2·8	3, B	2	48
Y_3 6052 ...	7·3	14 19	27 41	54	282·7	0·60	1·2	$4\frac{1}{2}$, $4\frac{1}{2}$	2	
τ_2 Lupi ...	4·4	14 20	44 56	55	176·7	0·30	...	...	3	49
Cordoba (35)	8·2	14 21	23 46	54	133·6	2·31	1·3	2, *b*	2	
P. 14^h 87 ...	5·6	14 24	44 52	58	309·9	10·4	4·4	...	1	50
β 1112 ...	6·0	14 27	30 16	56	6 0	2·36	3·0	4, *b*	2	
Lac. 5985 ...	7·0	14 27	32 53	54	158·7	14·2	4·0	4, B	2	41
h 4685 ...	9·0	14 28	45 43	37	80·0	2·40	0·8	—, *b*	2	22
h 4687 ...	7·7	14 29	36 6	57	91·2	1·54	0·1	...	2	51
a Lupi ...	5·4	14 31	45 42	50	25·2	19·2	...	4·2, B	2	
α Centauri...	0·2	14 33	60 25	11	211·1	...	...	...	1	87
				13	211·2	21·63	...	...	4	88
				31	211·3	21·66	...	3, 2	5	89
Innes 236 ...	5·6	14 43	72 47	52	101·6	1·82	2·0	$3\frac{1}{2}$, *b*	2	
h 4707 ...	7·7	14 46	66 0	53	118·6	0·58	0·3	3, 3	1	
Innes 226 ...	7·0	14 48	33 44	41	218·4	2·55	4·2	...	2	52
G.P.Z. 10498	8·8	14 49	70 32	52	347·3	2·03	1·6	...	2	53
Innes 328 ...	9·0	14 49	84 46	52	175·6	2·11	0·8	...	2	
„ 227 ...	7·3	14 50	34 14	41	89·8	0·40	0·3	3, 3	2	
„ 85 ...	8·5	14 59	35 32	55	182·8	0·80	0·9	...	2	
C.Z. 14^h 3790	8·3	15 1	42 43	51	182·3	1·89	0·2	2, 2	2	54
λ Lupi ...	4·3	15 2	44 54	56	193·4	0·61	0·3	2, 2	2	
Innes 238 ...	8·2	15 5	44 38	45	140·4	2·93	2·7	...	2	55
Lac. 6259 ...	6·3	15 9	60 34	31	317·6	10·7	...	...	1	56
h 4750 ...	7·3	15 9	47 40	38	19·9	13·3	3·0	...	1	
C.P.D. 5889	8·2	15 10	60 0	52	341·6	3·29	0·8	0, 0	3	57
Innes 370 ...	5·4	15 11	60 8	52	116·8	5·07	7·6	2, —	3	
„ 332 ...	6·6	15 12	67 7	53	107·2	1·21	2·0	3, —	1	
μ Lupi ...	4·2	15 12	47 30	45	155·1	1·50	0·0	3, 3	2	

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Innes 371	8·9	15 14	58 30	53	292·3	0·78	1·0	...	1	
Sellors 20	8·5	15 16	47 33	50	215·2	1·15	0·4	3, 3	3	58
Innes 87	9·2	15 19	38 24	31	245·2	1·20	0·2	3, 3	1	59
„ 239	7·0	15 23	31 8	32	356·4	0·48	0·4	0, 0	2	
„ 240	7·2	15 27	64 47	33	189·1	2·40	3·0	4, B	4	60
„ 241	8·0	15 28	64 12	36	19·1	9·94	4·0	...	1	61
γ Lupi	3·0	15 28	40 50	32	88·0	0·68	...	...	2	
Innes 89	6·8	15 34	39 39	33	148·6	1·31	1·0	...	1	
ι_1 Normæ	4·8	15 55	57 30	51	231·8	0·52	...	3, 3	1	62
λ 259	7·1	15 56	36 28	51	single	...	...	...	1	
Cordoba (43)	8·0	15 56	37 46	35	140·4	4·75	0·3	...	2	
h 4828	8·5	15 58	43 4	48	92·2	8·27	...	...	1	
Harvard	6·4	15 58	37 35	33	146·3	40·0	6·6	...	1	
Ref. Cat. 16^h 6					Is same as No. 5			...	...	
λ 266	7·2	16 3	35 23	51	single	...	...	...	1	
δ Tri. Aust.	4·0	16 6	63 26	51	„	...	...	...	1	63
λ 269	6·8	16 10	52 50	51	„	...	...	...	1	
Innes 15	7·0	16 11	64 24	40	315·2	1·01	2·5	...	2	22
λ Normæ	5·6	16 12	42 26	51	162·5	0·42	1·0	2, 2	1	64
λ 272	6·7	16 13	35 15	51	278·0	0·40	0·0	4, 4	1	
Ref. Cat. 16^h26	7·3	16 13	39 15	51	single	...	...	...	1	
λ 273	7·5	16 13	39 23	51	„	...	...	...	1	
Innes 91	6·3	16 14	39 11	50	295·4	10·7	2·9	...	2	
„ 93	7·7	16 19	47 49	51	287·6	0·95	2·5	...	1	65
„ 94	7·7	16 20	29 42	51	205·8	0·68	1·5	4, —	1	
„ 404	9·1	16 27	52 27	42	122·0	4·18	0·5	...	2	
Harvard	6·8	16 29	72 6	51	245·7	2·05	3·5	4, B	1	38
Innes 405	8·9	16 32	46 27	51	318·0	2·60	0·0	0, 0	1	
„ 97	8·5	16 34	48 34	43	single	...	...	...	2	
Lac. 6968	7·7	16 40	45 17	44	359·4	0·57	0·6	...	2	41
Innes 100	6·8	16 48	73 16	48	180·5	0·66	2·0	...	2	
„ 101	9·0	16 48	40 54	36	354·9	1·42	...	...	1	66
λ 316	6·4	16 53	48 30	48	185·6	0·63	1·0	5, 5	2	67
Cordoba (48)	7·0	16 55	50 1	51	234·6	8·00	...	...	1	
Innes 406	8·7	17 1	41 49	41	96·2	1·90	0·0	...	2	
„ 407	7·1	17 1	41 29	41	186·2	0·76	0·6	2, 2	2	
„ 246	7·5	17 4	27 39	49	33·5	1·29	3·2	2,—	3	
Cape 34	8·7	17 5	41 52	56	33·1	7·39	3·7	...	2	

Star.	Mag.	1900. R.A. h	m	S. Dec. °	′	1902·±	Pos. Angle. °	Dist. ″	Diff. of Mags.	Colours A.B.	No. of Nights.	Remarks.
h 4926 A–B	7·0	17	8	39	39	60	335·2	14·3	...	...	1	68
A–C						60	209·8	17·1	3·0	...	1	
Innes 229 ...	8·5	17	8	39	32	53	237·4	4·44	...	6, B	2	
„ 104 ...	6·5	17	9	69	56	51	132·9	2·10	...	3, B	1	
„ 408 ...	7·1	17	9	42	14	38	167·9	1·83	2·0	3, *b*	2	
λ 322	6·9	17	9	33	37	40	351·7	...	...	...	1	69
Brisbane ...	5·5	17	11	46	32	38	79·2	2·21	3·5	4, B	2	
β 416 = Mel.(4)	5·9	17	12	34	53	36	292·1	2·29	1·2	5, 5	3	
A–C						36	131·0	29·6	...	...	2	
C–D						33	48·7	35·5	D, 13^{m}	...	1	70
Innes 409 ...	8·8	17	12	39	40	33	37·2	5·12	2·0	...	1	
„ 410 ...	8·3	17	14	42	33	40	285·0	2·81	1·7	3, *b*	2	71
„ 385 A–B	7·5	17	16	59	7	51	167·7	0·44	1·5	...	1	72
AB–C						51	210·2	17·0	...	...	1	
γ Aræ	3·4	17	17	56	17	60	329·0	18·1	7·1	...	1	73
h 4949	5·3	17	19	45	45	43	262·1	2·61	1·0	2, 2	2	
Cape 29 ...	8·9	17	23	42	59	46	340·2	4·44	...	...	1	
Washburn 136	7·3	17	25	40	58	46	109·7	0·95	...	...	1	
Innes 247 ...	7·1	17	31	37	48	43	112·9	1·23	2·5	3, *b*	3	
„ 107 ...	8·9	17	33	32	18	33	137·9	1·60	0·3	...	1	
Lac. 7370 ...	6·9	17	35	56	58	40	108·9	1·14	2·0	...	1	74, 14
„ 7387 ...	6·8	17	38	59	57	40	...	...	...	...	1	75, 14
Cape 24 ...	8·6	17	41	45	0	48	330·0	3·94	...	...	2	
h 4978 ...	5·8	17	42	53	35	60	268·9	12·0	3·0	2, *b*	1	
h 4981 ...	9·0	17	42	50	15	57	17·9	2·25	0·2	0, 0	2	76
Innes 110 ...	7·5	17	52	47	46	37	126·6	1·54	2·0	3, B	2	77
Harvard ...	5·6	17	57	75	54	40	231·0	25·9	7·4	5, —	1	78
Lac. 7604 ...	7·7	18	7	50	20	51	144·9	0·34	0·4	2, 2	1	79
h 5033 ...	6·9	18	8	48	53	46	116·0	17·6	...	...	1	80
ξ Pavonis ...	4·2	18	14	61	32	51	150·1	3·28	4·0	6, *b*	1	
Cordoba [51]	7·9	18	16	42	49	46	138·3	3·33	...	...	1	
C.Z. XVIII. 1250 ...	8·7	18	22	46	22	51	39·8	1·76	0·0	...	1	81
δ_1 Telescopii	5·1	18	24	45	59	51	single	...	...	...	1	
Hargrave(317)	7·1	18	56	45	51	55	284·2	1·45	...	...	1	82
ζ Sagittarii ...	2·7	18	56	30	1	55	51·7	0·43	...	2, 2	1	
λ 403 A–B	7·2	19	57	36	20	55	single	...	...	...	1	83

Star.	Mag.	1900. R.A.	1900. S. Dec.	1902·±	Pos. Angle.	Dist.	Diff. of Mags.	Colours A.B.	No. of Nights.	Remarks.
		h m	° ′		°	″				
h 5168 ...	... 7·0	20 1	30 1	55	79·9	18·8	3·0	5, —	1	
C.P.D. 9113 ...	8·5	20 16	35 59	53	133·0	2·82	2·0	...	2	84
Russell 321 ...	6·7	20 20	37 44	53	83·4	1·31	2·2	3, *b*	2	85
Innes 379 A—B	5·9	20 59	73 34	46	...	...	...	...	2	86
„ AB—C				51	134·4	8·40	8·1	...	1	
„ 258	... 7·7	21 5	60 27	55	110·5	0·52	1·2	...	2	
„ 19	... 7·0	21 41	65 58	51	339·8	1·24	1·2	...	1	
„ 381	... 8·2	21 59	56 57	55	111·0	1·85	1·5	...	2	
„ 20	... 6·8	22 11	63 19	51	339·3	0·55	0·6	...	1	
Cordoba (63) ...	6·5	22 37	47 43	58	132·2	7·70	...	...	1	

Remarks.

No.

1. B is purplish.
2. Epoch, 1901·01, omitted last year by error.
3. Found on a triple chart plate and estimated as follows:—1898, 280° ±, 16″ ± comp. about 11ᵐ. Also seen in the 18-in.; but the comp. was too faint to measure. The an. prop. mot. of the chief star is 0″·092 towards 150°·8. Innes 412.
4. Found in 1896 by Mr. W. H. Cox at the T. Circle. Cape 38.
5. Innes 413. Found with the 7-in. About 25′ S.f. *β* 311.
6. Innes 414. This close pair was found with the 7-in. and confirmed with the 18-in. The p.m. is under 0″·01.
7. Cape 39. Found by Mr. Cox at the Transit-Circle.
8. Not too sure.
9. Colours very fine.
10. Most difficult.
11. A 12ᵐ·5 star at 320° ±, 18″ ±, several other faint stars near.
12. No third comp. seen.
13. Wrongly identified in Ref. Cat.; is C.Z. 8ʰ, 2233.
14. The prop. mot. is very small.
15. P. M. = $\alpha + 0^{s}\cdot001$, $\delta - 0''\cdot01$.
16. Always most difficult, distance decreasing. Recent measures are:—

1897·1	256°·1	0″·56	See and Cogshall.
1899·3	275·0	0·72	Aitken.
1900·3	292·8	0·76	Cape.
1901·2	307·2	0·70	„
1902·2	338·8	0·48	„

17. New = Cape 40. Found by Mr. J. Power at the T. C. A 13ᵐ·5 star, 230° ±, 9″ ± from A; is 5″ ± from B. The mag. of A is from the C.P.D., the Cor. DM. has 9ᵐ·5. My estimate was 8ᵐ·3.
18. Smaller component precedes. In 1901·09 I found this star to be single.
19. The star measured for Innes 290 on 1901·09 is C.P.D.—59°, 1718. C.P.D.—59°, 1699 and 1718 = Innes 415 and 416 were measured by accident for Innes 290. In a cluster containing many small pairs.
20. Distance on 1900·22:—for 35″·1 read 26″·1, error of reduction.
21. Transit-Circle double star = Cape 41.
22. Colours slightly contrasted.

No.

23. Another *comes* at 20″ (not 20′, as in Ref. Cat.).
24. Epoch 1901·18, omitted in 1901 list. Angle decreasing?
25. Another *comes* $13\frac{1}{2}$ mag., 235° ±, 15″ ±.
26. A−B added with the 18-in. = Innes 417.
27. New = Innes 418. Found with the 7-in. There is a faint wide pair N.f. The prop. mot. is uncertain, as the observations available are discordant.
28. New = Innes 419. Found with the 7-in. This pair is in the magnificent cluster around *x Carinæ*, and is not fainter than $8^m{\cdot}5$; but C.G.A. gives $9\frac{3}{4}^m$, C.P.D. $9^m{\cdot}2$. It is No. 483 of Gould's Cordoba Photographs of the cluster, but it is not identified; mag. there = 9·5.
29. A 14^m star, 10° ±, 28″ ±.
30. Picked up with the 18-in = Innes 420. It is the following of two stars near the variable R. S. Centauri.
31. New = Innes 421. Found with the 7-in. Many faint stars within 40″.

31A. New quadruple star = Innes 422. C was found with the 7-in. The chief star was found to be double, and D added with the 18-in. The angles for A−B are discordant, viz. 89°·1, 101°·7, and 91°·5.

32. Both components single.
33. New = Innes 423. Found with the 7-in. The prop. mot. is very small.
34. In 1901 angle to read 344°·0 and not 334°·0, as printed.
35. The prop. mot. is 0″·083 towards 232°·9.
36. λ 89. No compn. seen. Is perhaps a misidentification of the star Ref. Cat. 7^h No. 71.
37. P.m. = 0″·09 towards 263°·7.
38. The companion was not seen here in 1901.
39. P.m. = 0″·21 towards 349°·3.
40. Poor measures, as the faint star was difficult to see. See has 29″·8, which would seem to be too small by 10″.
41. Found by Prof. Bailey at Arequipa and kindly communicated by Prof. E. C. Pickering.
42. Prop. mot. = 0″·10 towards 270°. This star is called "double" in Brisbane, but unless there has been much change the present companion could not have been seen at Parramatta.
43. Added with the 18-in. = Innes 424. λ 170, See's comp. at 0″·34 was not seen, but the chief star had perhaps a very doubtful elongation towards 130°. Professor See did not observe the new *comes*; but it is a difficult object, on account of the disparity of magnitude, and could be very easily overlooked, as indeed it was by myself in 1901 when measuring the distant star noted at Arequipa in 1891.
44. Transit-Circle pair = Cape 42.
45. New = Innes 425. Found with the 18-in.
46. Prop. mot. = 0″·19 towards 145°·7. Change of position-angle = 19° in two years.
47. A 13th mag. star about midway between A and C.
48. Prop. mot. = 0″·04 towards 257°·2.
49. ,, = 0″·04 ,, 244°·0.
50. ,, = 0″·077 ,, 270°·0. Found with the 18-in. = Innes 426.
51. Angle increasing slowly; distance decreasing.
52. The *comes* was not seen in 1901. A fainter star 30″ in same direction.
53. New = Innes 427, found with the 18-in.
54. New = Cape 43. Found at the Transit-Circle. Mag. from C.P.D. Cor. DM. has $9^m{\cdot}0$, which is too faint. A 12^m star is S.f. Prop. motion of the chief star = 0″·06 towards 190°·0.
55. Prop. mot. = 0″·03 towards 288°·0. There is an $11^m{\cdot}5$, 310° ±, 20″ ±.
56. This was also measured in 1901 for δ Circini. The Arequipa *comes* to the latter star was estimated 12^m, 270° ±, 50″ ±, when the former was measured. Lac. 6259 = Innes 428.

No.

57. Found by Mr. W. H. Cox at the T.-C. = Cape 44.
58. Large common prop. mot. of 0″·47, but relatively fixed.
59. This star has been elsewhere misidentified and measured as λ 236.
60. Perhaps the chief star is elongated towards 232°.
61. This is the only near companion.
62. Is λ 258. This fine pair has decreased in angle 35° since 1897.
63. The Arequipa *comes* 20″ S.f. seen. I would suggest that the estimate of 1880 has been misprinted, and should read 140° ±, 30″ ±.
64. Is λ 271, in 1897 angle = 152°. P.m. = 0″·03 towards 225°.
65. Com. prop. mot. of 0″·09 towards 257°·5.
66. Distance in 1900 to read 1″·35. Colours slightly contrasted.
67. P.m. = α − 0ˢ·004 sec., δ − 0″·10.
68. The changes indicated by Prof. See's measures in 1896 are not confirmed. For A−B the micrometer was set to 331°·8 (Prof. See's angle), but the disagreement was very evident. Prof. See also measured the chief star as a double (0″·6) on two nights. It is now certainly single.
69. Elongation doubtful, still the star does not look single. The measures were fairly accordant (1897, 361°·3, 0″·2, See, 1*n*).
70. The *comes* D was added in 1897 by Professor See. Transferring the Cape measure to A we have for comparison:—

A−D,	1897·4	86°·1	55″·4	See. 1*n*.
„	1902·3	84·4	49·8	Innes. 1*n*.

This change is exactly accounted for by the proper motion of the triple system A−B−C; hence D is not connected with the system.

71. Prop. mot. = α + 0ˢ·001, δ −0″·09.
72. It is unfortunate that only one night's obs. of this system could be procured both in 1900 and 1902. We have:

1900·72	184°·3	0″·51
1902·51	167·7	0·44

73. A 12½-mag. *comes* at twice the distance.
74. Found by Mr. Clymer at Arequipa and kindly communicated by Prof. E. C. Pickering.
75. Suspected by Mr. Clymer. If double, certainly under 0″·4 if components are sensibly equal in mag. the star looks single.
76. This star is C.Z. xvii., 2739. Lac. 7437, mag. 7·5, is 46 secs. f.
77. Prop. mot. = α − 0ˢ·008, δ − 0″·03.
78. „ „ = 0″·26 towards 184°·0.
79. Found with the 7-in. = Innes 429. Prop. mot. = 0″·09 towards 257°·5.
80. This pair, with two other stars, form an isolated rhomboid. There is no material for the determination of proper motion, but it cannot be large.
81. Found at the Transit-Circle = Cape 45.
82. Prop. mot. = 0″·04 towards 194°·0, in which the *h* companion probably shares.
83. This pair is under 0″·4 if double. Prof. See's third component was also invisible. There is a 13th-mag. star 15″ N. pr. not noticed by Prof. See.
84. Found in 1897 = Innes 430. There is a 9ᵐ star 4ˢᵉᶜˢ. pr., 1′·3 S. Lac. 8406, mag. 68 is 1ᵐⁱⁿ. pr.

No.

85. This fine pair has a com. prop. mot. of 0″·341 towards 245°·8. The measures are :—

1880·9	97°·0	1″·07	Russell.	1*n*.
1890·7	96·0	1·08	Sellors.	1
1896·7	99·7	0·78	See.	3
1902·5	83·4	1·31	Innes.	2

On the occasion of the last measure the wire was purposely set at 99°, but it was impossible; query if in 1896, a misprint for 89°.

86. The close pair was estimated 318° and 240° on two occasions. Probably single at present.

87. Day. By Sir D. Gill.

88. Day.

89. Night.

Cometary Observations at the Liverpool Observatory. By W. E. Plummer, M.A

Observations of Comet b 1902 (Perrine).

Greenwich Mean Time of Observation.				♂ − ✶ Ret.	No. of Comp.	Apparent R.A. of ♂.			♂ − ✶ Decl.	No. Comp.	App. Decl. of ♂.			Log. Factor of Parallax *a*.	Log. Factor of Parallax *δ*.	Star of Comp.
		h	m	s	m s		h	m	s			°	′	″			
Sept.	3	10	22	50·4	−2 19·45	35	3	15	36·34	− 3	0·3	5	+35	37	15·2	−9·6345	0·7635	*a*
		10	22	50·4	−3 35·69	25	3	15	36·40	− 3	1·7	5	+35	37	15·9	−9·6345	0·7635	*b*
	4	10	27	46·0	−2 40·61	16	3	14	29·42	+ 3	27·7	5	+36	3	19·7	−9·6369	0·7615	*c*
	5	10	2	35·1	− 0·49	20	3	13	15·95	− 1	4·4	5	+36	30	8·0	−9·6370	0·7774	*d*
		10	2	35·1	+1 14·02	20	3	13	15·89	+ 1	47·2	5	+36	30	8·8	−9·6370	0·7774	*e*
	6	10	40	26·0	+2 47·41	16	3	11	50·32	+ 5	9·5	4	+36	59	26·9	−9·6412	0·7315	*f*
	8	10	2	16·9	−2 5·10	20	3	8	37·26	− 1	46·4	5	+37	59	57·8	−9·6477	0·7551	*g*
	18	10	4	31·2	+ 3·45	15	2	35	28·36	+ 1	25·2	6	+45	6	1·1	−9·6787	0·5948	*h*
	19	10	29	24·8	−2 29·10	16	2	29	22·18	− 4	10·9	5	+46	3	53·4	−9·6614	0·5173	*i*
	23	8	18	16·0	−2 41·71	16	1	56	28·92	+ 3	26·2	5	+50	14	1·2	−9·7388	0·6558	*j*
	24	8	2	0·3	+ 3·90	15	1	44	49·89	− 4	34·3	4	+51	22	43·3	−9·7485	0·6136	*k*
	25	7	47	10·9	+ 1·86	15	1	31	20·92	− 1	42·2	6	+52	31	55·2	−9·7592	0·5962	*l*
	26	7	30	30·1	−2 4·68	16	1	15	46·55	− 4	16·9	6	+53	39	46·7	−9·7677	0·5394	*m*
	28	9	3	20·1	− 6·79	16	0	34	55·64	−14	16·7	5	+55	46	2·9	−9·6530	9·9772	*n*
Oct.	1	7	25	45·7	+2 43·07	10	23	15	18·99	− 6	39·9	3	+57	0	38·0	−9·6893	9·9654	*o*
	2	7	31	16·3	+1 52·99	15	22	43	21·66	− 3	46·8	5	+56	34	14·9	−9·5900	9·6037	*p*
	5	7	14	11·2	+5 3·24	12	21	8	49·92	+ 4	43·7	4	+51	41	55·9	−9·1762	9·5806	*q*
		7	14	11·2	+4 32·89	12	21	8	50·25	+ 2	12·3	4	+51	41	58·0	−9·1762	9·5806	*r*
	8	7	26	10·4	+ 27·43	16	19	54	30·45	−	20·8	5	+42	22	22·9	+8·8893	0·2304	*s*
	11	7	6	29·2	−1 7·84	12	19	5	21·88	− 6	52·7	3	+31	46	44·7	+9·1434	0·5592	*t*

Sept. 3. The comet presents a well-marked condensation to which the observations refer. Sept. 8. The sky somewhat cloudy, but the comet fairly well seen. Sept. 18. Moonlight troublesome. Sept. 28. Connected with *α Cassiopeiæ* by means of an intermediate star; the observation not very satisfactory. Oct. 5. Sky hazy, comet faint; found with difficulty.

Mean Places of Stars of Comparison.

Star's Designation or Authority.	Mean R A. 1902·0.	Corr. to Apparent Equinox.	Mean Decl. 1902·0.	Corr. to Apparent Equinox.	Letter of Reference.
	h m s	s	° ′ ″		
A. G. C. (Lund) No. 1747	3 17 51·81	+3·98	+35 40 14·6	+ 0·9	*a*
,, ,, No. 1762	3 19 8·12	+3·97	+35 40 16·8	+ 0·8	*b*
,, ,, No. 1744	3 17 5·98	+4·05	+35 59 50·4	+ 1·6	*c*
,, ,, No. 1712	3 13 12·34	+4·10	+36 31 11·0	+ 1·4	*d*
,, ,, No. 1700	3 11 57·77	+4·10	+36 28 20·2	+ 1·4	*e*
,, ,, No. 1673	3 8 58·75	+4·16	+36 54 15·6	+ 1·8	*f*
,, ,, No. 1688	3 10 38·09	+4·27	+38 1 42·6	+ 1·6	*g*
A. G. C. (Bonn) No. 2271	2 35 19·83	+5·08	+45 4 30·7	+ 5·2	*h*
,, ,, No. 2219	2 31 46·08	+5·20	+46 7 58·6	+ 5·7	*i*
,, ,, No. 1769	1 59 5·19	+5·44	+50 10 27·5	+ 7·5	*j*
A. G. C. (Cambridge, Mass.) No. 846	1 44 40·23	+5·76	+51 27 6·3	+11·3	*k*
,, ,, ,, No. 722	1 31 13·20	+5·86	+52 33 24·4	+13·0	*l*
,, ,, ,, No. 618	1 17 45·24	+5 95	+53 43 48·9	+14·7	*m*
a Cassiopeiæ	0 34 56·44	+5·99	+55 59 59·6	+20·0	*n*
A. G. C. (Helsingfors) No. 13903	23 12 30·60	+5·32	+57 6 48·9	+29·0	*o*
,, ,, ,, No. 13398	22 41 23·80	+4·87	+56 37 30·1	+31·6	*p*
A. G. C. (Cambridge, Mass.) No. 6906	21 3 43·39	+3·29	+51 36 36·5	+35·7	*q*
,, ,, ,, No. 6908	21 4 14·06	+3·30	+51 39 10·0	+35·7	*r*
A. G. C. (Bonn) No. 13585	19 54 0·61	+2·41	+42 22 28·3	+33·8	*s*
Leiden Zones, 65 No. 70	19 6 27·62	+2·10	+31 53 8·0	+29·4	*t*

On Jacobi's Method of Facilitating the Numerical Solution of Equations arising in the Theory of Secular Perturbations.

By H. C. Plummer, M.A.

1. The equations to be considered here are of the type

$$\Delta = 0$$

where Δ is a symmetric determinant which may be written in the form

$$\begin{vmatrix} A_{11}-\lambda, & A_{12}, & \dots & A_{1n} \\ A_{21}, & A_{22}-\lambda, & \dots & A_{2n} \\ — & — & \dots & — \\ A_{n1}, & A_{n2}, & \dots & A_{nn}-\lambda \end{vmatrix}$$

and which is no other than the familiar discriminating determinant which occurs in so many branches of mathematics. As it arises in the determination of the mean motions of the perihelion and the node, the number of rows and columns corresponds to the number of the planets. In the application to the solar system the determinant is of the eighth order; and little reflexion is necessary to see that its direct reduction would entail enormous labour. Hence Jacobi's method* of approximating to the numerical values of the roots without reducing the determinant is of great practical interest.

2. The principle of Jacobi's method may be briefly recalled. The vanishing of Δ is the condition of the consistency of the system of n linear equations

$$\begin{aligned} (A_{11}-\lambda)x_1 + A_{12}x_2 + \dots + A_{1n}x_n &= 0 \\ \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot & \\ A_{n1}x_1 + A_{n2}x_2 + \dots + (A_{nn}-\lambda)x_n &= 0 \end{aligned}$$

where $A_{rs} = A_{sr}$. Let $[i]$ and $[k]$ denote the ith and kth equations. The substitution

$$\begin{aligned} x_i &= \chi_i \cos\alpha - \chi_k \sin\alpha \\ x_k &= \chi_i \sin\alpha + \chi_k \cos\alpha \end{aligned}$$

is made and $[i]$ and $[k]$ are replaced by $[i]\cos\alpha + [k]\sin\alpha$ and $-[i]\sin\alpha + [k]\cos\alpha$. Then if

$$\cot 2\alpha = (A_{kk} - A_{ii})/2A_{ik}$$

the eliminant of the equations thus transformed is a symmetric determinant of exactly the same *form* as before. If A'_{rs} be the constituent corresponding to A_{rs} in the transformed determinant, we have

* 'Über ein leichtes Verfahren die in der Theorie der Säcularstörungen vorkommenden Gleichungen numerisch aufzulösen,' *Werke*, vol. vii. p. 111; Crelle, vol. xxx. (1846), p. 64.

$$A'_{ik} = A'_{ki} = 0$$
$$A'_{ii}{}^2 + A'_{kk}{}^2 = A_{ii}{}^2 + A_{kk}{}^2 + 2A_{ik}{}^2$$
$$A'_{ij}{}^2 + A'_{kj}{}^2 = A_{ij}{}^2 + A_{kj}{}^2,\ j \neq i \neq k.$$

The result of the transformation is therefore to annihilate two equal constituents and to leave unaltered the sum of the squares of the other constituents outside the leading diagonal. The process can be repeated until the sum of the squares of the constituents becomes very small except in the leading diagonal, the constituents in which approximate to the factors of the determinant, and will accordingly give the roots of the equation. The approximations to the roots after a certain number of transformations can be completed by a different process, also due to Jacobi.

3. It may be interesting to study the theory underlying this method in a more general manner. For this purpose let the determinant Δ be multiplied by

$$\delta = \begin{vmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{vmatrix}$$

the mode of composition being by rows of each determinant in such a way that rows of Δ appear in the corresponding rows of $\delta\Delta$. The constituent in the jth row and sth column of the product

$$= \sum_{i=1}^{i=n} A_{ji}\, a_{si} - \lambda a_{sj}$$

Next let the determinant $\delta\Delta$ be multiplied by δ, the mode of composition being by columns of $\delta\Delta$ and rows of δ. The constituent in the r^{th} row and s^{th} column of the final product

$$= \sum_{j=1}^{j=n} a_{rj} \left[\sum_{i=1}^{i=n} A_{ji}\, a_{si} - \lambda .\ a_{sj} \right]$$
$$= \sum_{i=1}^{i=n} \sum_{j=1}^{j=n} A_{ji}\, a_{si}\, a_{rj} - \lambda . \sum_{j=1}^{j=n} a_{rj}\, a_{sj}.$$

This expression is unaltered by the interchange of r and s, and therefore the resulting determinant is symmetrical.

4. The determinant $\delta^2\Delta$ is not only symmetrical but is also of precisely the same form as Δ, provided that

$$\sum_{j=1}^{j=n} a_{rj}{}^2 = 1,\ (r = 1, 2, \dots, n)$$
$$\sum_{j=1}^{j=n} a_{rj}\, a_{sj} = 0,\ (r, s = 1, 2, \dots, n\ ;\ r \neq s)$$

That is, provided that δ is the modulus of an orthogonal transformation scheme

$$x_1 = a_{11}\, y_1 + a_{21}\, y_2 + \dots + a_{n1}\, y_n$$
$$\dots\dots$$
$$x_n = a_{1n}\, y_1 + a_{2n}\, y_2 + \dots + a_{nn}\, y_n$$

which is such that

$$x_1^2+x_2^2+\ldots+x_n^2 \equiv y_1^2+y_2^2+\ldots+y_n^2$$

If these conditions are fulfilled, with their well-known consequences, and if

$$\sum_{i=1}^{i=n}\sum_{j=1}^{j=n} A_{ji}\, a_{si}\, a_{rj} = B_{rs}$$

then $\delta^2\Delta =$

$$\begin{vmatrix} B_{11}-\lambda, & B_{12}, & \ldots & B_{1n} \\ B_{21}, & B_{22}-\lambda, & \ldots & B_{2n} \\ \cdots & \cdots & \ldots & \cdots \\ B_{n1}, & B_{n2}, & \ldots & B_{nn}-\lambda \end{vmatrix}$$

is identically equal to Δ, for $\delta^2 = 1$.

5. A number of identities may be deduced from this result. The coefficient of $(-\lambda)^{n-1}$ in Δ is

$$A_{11}+A_{22}+\ \ldots\ +A_{nn} = \Sigma A_{rr}$$

Hence $$\Sigma A_{rr} = \Sigma B_{rr}$$

Again the coefficient of $(-\lambda)^{n-2}$

$$= \Sigma(A_{rr}A_{ss}-A_{rs}^2)$$

Hence

$$[\Sigma A_{rr}]^2 - 2\Sigma(A_{rr}A_{ss}-A_{rs}^2)$$
$$= [\Sigma B_{rr}]^2 - 2\Sigma(B_{rr}B_{ss}-B_{rs}^2)$$

which gives

$$\Sigma A_{rr}^2 + 2\Sigma A_{rs}^2 = \Sigma B_{rr}^2 + 2\Sigma B_{rs}^2$$

That is to say, the sum of the squares of the constituents is the same in both determinants. Moreover, the sum of the squares of the constituents in the rth row or column of $\delta^2\Delta$ is

$$\Sigma_s B_{rs}^2 = \Sigma_s(\Sigma_j\Sigma_i A_{ji}a_{si}a_{rj})^2$$
$$= \Sigma_s\Sigma_j\Sigma_i\Sigma_k\Sigma_l A_{ji}A_{kl}a_{rj}a_{rk}a_{si}a_{sl}$$
$$= \Sigma_i\Sigma_j\Sigma_k A_{ji}A_{ki}a_{rj}a_{rk}$$

for $\Sigma_s a_{si}a_{sl} = 0$ unless $l = i$, in which case the sum is unity.

6. The conditions which the n^2 coefficients of an orthogonal transformation must satisfy are $\frac{1}{2}n(n+1)$ in number. They can be so chosen as to satisfy in addition the $\frac{1}{2}n(n-1)$ conditions.

$$B_{rs} = \sum_{i=1}^{i=n}\sum_{j=1}^{j=n} A_{ji}\, a_{si}a_{rj} = 0, (r, s = 1, 2, \ldots, n;\ r \neq s)$$

Then all the constituents outside the leading diagonal of $\delta^2\Delta$ vanish, and the roots of the equation in λ become $B_{11}, B_{22}, \ldots, B_{nn}$, where

$$B_{rr} = \sum_{i=1}^{i=n}\sum_{j=1}^{j=n} A_{ji}a_{ri}a_r$$

But the complete solution of the equation $\Delta = 0$ is required in order to find the coefficients of the substitution. The additional relations given above show that

$$A_{11}x_1^2 + A_{22}x_2^2 + \ldots + 2A_{12}x_1x_2 + \ldots \equiv B_{11}y_1^2 \ldots + B_{nn}y_n^2$$

i.e. the substitution is one which transforms the quadratic form into a sum of square terms. Hence

$$(A_{11}-\lambda)x_1^2 + (A_{22}-\lambda)x_2^2 + \ldots + 2A_{12}x_1x_2 + \ldots \equiv (B_{11}-\lambda)y_1^2 + \ldots + (B_{nn}-\lambda)y_n^2$$

If now $\lambda = B_{rr}$, y_r disappears, and therefore

$$x_1\left[(A_{11}-\lambda)\frac{\partial x_1}{\partial y_r} + A_{12}\frac{\partial x_2}{\partial y_r} + \ldots + A_{1n}\frac{\partial x_n}{\partial y_r}\right] + x_2\left[A_{21}\frac{\partial x_1}{\partial y_r} + (A_{22}-\lambda)\frac{\partial x_2}{\partial y_r} + \ldots + A_{2n}\frac{\partial x_n}{\partial y_r}\right] + \ldots \equiv 0$$

Hence

$$(A_{11}-\lambda)a_{r1} + A_{12}a_{r2} + \ldots + A_{1n}a_{rn} = 0$$
$$A_{21}a_{r1} + (A_{22}-\lambda(a_{r2} + \ldots + A_{2n}a_{rn} = 0$$
$$\ldots\ldots\ldots\ldots\ldots\ldots$$

These lead again to the equation $\Delta = 0$. The successive substitution of the roots of the latter equation in λ in the set of linear equations will yield the n sets of n coefficients.

7. It is thus seen that the complete transformation requires a knowledge of the roots of the very equation whose solution is to be effected. But it is possible to use a partial transformation instead of a complete one. The set of quantities $x_1, \ldots, x_n$ can be divided into two sets $x_1, \ldots, x_m$ and $x_{m+1}, \ldots, x_n$ of which the former is transformed as before, while the latter remains unchanged. This means that the terms of $\sum_i\sum_j A_{ji}x_ix_j$ which involve the first set only are transformed into a sum of squares, those involving the second set only are unchanged, and the product terms involving one quantity from each set retain their form with changed coefficients. The transformation as a whole, as well as in part, remains orthogonal, but the coefficients of the substitution are such that $a_{si} = 0$ ($s \neq i$; s or $i > m$) and $a_{ss} = 1$ ($s > m$). Three cases must be considered separately, and these results are easily deduced from the formula of § 3 :

(1) If $r > m$, $s > m$, then

$$B_{rs} = A_{rs}$$

(2) If $r > m$, $s \not> m$, then

$$B_{rs} = \sum_{i=1}^{i=m} A_{ri}\, a_{si}$$

(3) If $r \not> m$, $s \not> m$, then

$$B_{rs} = \sum_{j=1}^{j=m}\sum_{i=1}^{i=m} A_{ji}a_{si}a_{rj}$$

8. It is now possible to choose the m^2 quantities $a_{si}(s \geqslant m, i \geqslant m)$ according to the method of § 6 so as to make the terms $B_{rs}(r \neq s)$ of § 7 (3) vanish. In this way all the constituents of the minor formed of the first m rows and columns of Δ outside the leading diagonal can be made to vanish. Since by interchange of rows and columns the constituents of the leading diagonal can be made to take any order, it is clear that any minor on the leading diagonal can be transformed in this way. If the minor is a determinant of the mth order, the solution of an equation of the mth degree is required for the transformation and $m(m-1)$ constituents can be made to vanish. To the transformed minor the results of §§ 3–6 apply. The complementary minor on the leading diagonal will remain unaltered. As regards the outstanding constituents it is easily deduced either from § 7 (2) or from the formula in § 5 that the sum of the squares of constituents lying in a line parallel to a row or column of the transformed minor remains unaltered. This is the generalisation of the fact on which the principle of Jacobi's method depends. The sum of the constant terms in the axis of the transformed minor is unchanged, while the sum of their squares is increased by the sum of the vanishing constituents. Outside this minor the sum of the squares of the constituents is left, line for line, unchanged. Hence repetition of the process must cause the axial terms to approximate to the factors of the determinant.

9. Jacobi's method amounts to the use of the case in which $m = 2$. The auxiliary angle α which is introduced in § 2 has of course a simple geometrical meaning. It is the angle between the coordinate axes and the axes of the conic

$$A_{ii}x^2 + 2A_{ik}xy + A_{kk}y^2 = 1$$

and its connexion with the substitution theory is obvious. In Jacobi's method it is always possible to remove the numerically greatest pair of constituents outside the diagonal at each transformation. Hence if S is the sum of the $n(n-1)$ squares after the first transformation the square of the greatest $> S/(n-2)(n+1)$, and each further transformation will reduce the sum of the squares faster than in the ratio

$$1 : 1 - \frac{2}{(n-2)(n+1)}$$

In the general case of m substitutions the $m(m-1)$ constituent to be removed cannot be chosen independently, and after a certain number of transformations it may be necessary to include terms previously reduced. Short of this event the ratio of decrease of the sum of the squares may be expected to be at least

$$1 : 1 - \frac{m(m-1)}{(n-m)(n+m-1)}$$

Doubtless Jacobi's case is the simplest, but it would be theoretically possible to make $m = 4$, a case involving the solution of a biquadratic and removing twelve constituents. The case of $m = 3$, depending on a cubic and removing 6 constituents, would seem to be quite practicable and useful at least in the earlier transformations. In any case, when the factors of any axial minor are known, all the constituents of that minor outside the axis can be removed. The necessary substitutions might probably be facilitated by the use of an arithmometer. But after the work of Harzer, who employed Jacobi's method, it is unlikely that an occasion for employing such processes will recur.

10. The principle of Jacobi's method contains implicitly a proof that the roots of a discriminating determinant are real. The proof supposes the method repeated an infinite number of times. The idea of a limit may be avoided by the foregoing theory. For this it is only necessary to notice that if the extra-diagonal terms of a minor of any order be removed as before explained, it is possible to extend the process to a minor of an order higher by unity. That is to say, the process can be extended successively from a minor of the second order, for which it is always possible, to the complete determinant. For let the extra-diagonal constituents of Δ be zero except in the first row and column. Then

$$\Delta = \left[1 - \frac{A_{12}^2}{(A_{11}-\lambda)(A_{22}-\lambda)} - \frac{A_{13}^2}{(A_{11}-\lambda)(A_{33}-\lambda)} - \ldots\right]\Pi$$

where Π is the product of the diagonal terms. In Δ put $\lambda = A_{rr}$. Then

$$\Delta = -A_{1r}^2 (A_{22}-A_{rr})(A_{33}-A_{rr}) \ldots (A_{nn}-A_{rr})$$

Suppose that A_{22}, A_{33} . . . are in increasing order of magnitude. If now λ is put equal to $-\infty$, A_{22}, A_{33}, . . ., A_{nn}, $+\infty$ in turn, it is easily seen that the resulting values of Δ are of alternating sign, and therefore Δ has real roots situated between the values, assigned to λ. And if A_{22}, A_{33}, . . . are not all different, the roots are still real. For if, for example, $A_{22} = A_{33}$, the expanded form of Δ shows that A_{22} is a root, and the order of Δ can be depressed by writing $A_{22}-\lambda$ only once in the diagonal and $\sqrt{[A_{12}^2 + A_{13}^2]}$ in the corresponding places of the first row and column. Hence, generally, a determinant of the form considered has real roots, and its extra-diagonal constituents can all be removed by a real substitution. Thus by successive steps it is proved that the roots of any discriminating determinant are real. It is not difficult to see that a similar method could be applied to the more general case of Langrange's determinant.

University Observatory, Oxford:
1902 *December* 6.

Ephemeris for Physical Observations of

Greenwich Noon.	P.	L−O.	B.	Apparent Diameter. Equat. 2a.	Defect.	Polar 2b.	d.	Q.	B′.
1903.	°	°	°	″	″	″	°	°	°
Mar. 28	335·811	203·012	+0·928	34·08	0·07	31·88	5·40	246·36	+0·99
30	335·752	203·463	0·956	34·17	0·08	31·96	5·67	246·36	1·02
April 1	335·695	203·910	0·984	34·26	0·09	32·05	5·94	246·37	1·05
3	335·640	204·354	1·012	34·36	0·10	32·14	6·20	246·37	1·08
5	335·587	204·795	1·039	34·46	0·11	32·24	6·46	246·38	1·11
7	335·535	205·230	1·065	34·57	0·12	32·35	6·72	246·39	1·14
9	335·485	205·663	1·091	34·68	0·13	32·45	6·97	246·40	1·17
11	335·436	206·091	1·116	34·80	0·14	32·56	7·22	246·40	1·19
13	335·388	206·514	1·141	34·92	0·15	32·67	7·46	246·41	1·22
15	335·343	206·934	1·165	35·04	0·16	32·79	7·70	246·42	1·24
17	335·300	207·347	1·188	35·17	0·17	32·91	7·94	246·42	1·27
19	335·258	207·757	1·211	35·30	0·18	33·03	8·17	246·43	1·29
21	335·218	208·162	1·233	35·44	0·19	33·16	8·39	246·43	1·32
23	335·180	208·560	1·254	35·58	0·20	33·30	8·61	246·44	1·34
25	335·144	208·954	1·275	35·73	0·21	33·44	8·82	246·44	1·36
27	335·109	209·341	1·295	35·89	0·22	33·58	9·03	246·45	1·38
29	335·075	209·724	1·315	36·05	0·23	33·73	9·24	246·45	1·41
May 1	335·043	210·098	1·335	36·22	0·24	33·88	9·43	246·46	1·43
3	335·012	210·468	1·355	36·39	0·25	34·04	9·62	246·46	1·45
5	334·982	210·830	1·375	36·56	0·26	34·20	9·80	246·47	1·47
7	334·956	211·186	1·395	36·74	0·28	34·37	9·98	246·47	1·49
9	334·931	211·535	1·415	36·92	0·29	34·54	10·15	246·48	1·51
11	334·907	211·877	1·435	37·11	0·30	34·72	10·31	246·48	1·53
13	334·883	212·211	1·454	37·30	0·31	34·90	10·46	246·49	1·55
15	334·859	212·538	1·474	37·49	0·32	35·08	10·61	246·49	1·57
17	334·837	212·858	1·493	37·69	0·33	35·27	10·75	246·50	1·59
19	334·817	213·169	1·512	37·90	0·34	35·46	10·88	246·51	1·62
21	334·798	213·472	1·531	38·11	0·35	35·66	11·00	246·52	1·64
23	334·780	213·767	1·550	38·33	0·36	35·86	11·12	246·53	1·66
25	334·764	214·052	1·569	38·55	0·37	36·06	11·22	246·55	1·68
27	334·749	214·330	1·588	38·77	0·38	36·27	11·32	246·56	1·70
29	334·735	214·597	1·606	39·00	0·39	36·48	11·41	246·58	1·71
31	334·722	214·855	1·624	39·23	0·39	36·70	11·49	246·60	1·73
June 2	334·710	215·103	1·641	39·47	0·40	36·92	11·55	246·62	1·75
4	334·698	215·343	+1·659	39·71	0·40	37·15	11·61	246·64	+1·77

Jupiter, 1903–4. By A. C. D. Crommelin.

Greenwich Noon.	Longitude of Ⅱ's Central Meridian. 877°·90 I.	870°·27 II.	Corr. for Phase.	Light-time.	A − O.	*B*.
1903.	°	°	°	m	°	°
Mar. 28	296·07	299·67	+0·13	48·743		
30	251·49	239·84	·14	48·617		
Apr. 1	206·93	180·01	·15	48·486	197·969	+0·950
3	162·37	120·19	·17	48·349		
5	117·82	60·38	·18	48·206		
7	73·27	0·57	·19	48·057		
9	28·73	300·77	·21	47·902		
11	344·20	240·98	·23	47·742	198·866	0·996
13	299·68	181·20	·24	47·578		
15	255·17	121·42	·26	47·409		
17	210·66	61·65	·28	47·233		
19	166·16	1·89	·29	47·053		
21	121·67	302·14	·31	46·868	199·763	1·041
23	77·19	242·40	·32	46·678		
25	32·71	182·66	·34	46·483		
27	348·24	122·93	·35	46·283		
29	303·78	63·21	·37	46·079		
May 1	259·33	3·50	·39	45·871	200·662	1·087
3	214·89	303·80	·40	45·658		
5	170·46	244·11	·42	45·441		
7	126·04	184·43	·43	45·222		
9	81·63	124·76	·45	44·997		
11	37·23	65·10	·46	44·771	201·561	1·132
13	352·84	5·44	·48	44·541		
15	308·45	305·79	·49	44·307		
17	264·07	246·15	·50	44·070		
19	219·71	186·52	·52	43·831		
21	175·36	126·90	·53	43·590	202·462	1·176
23	131·02	67·29	·55	43·345		
25	86·68	7·70	·56	43·098		
27	42·35	308·12	·56	42·848		
29	358·04	248·54	·57	42·597		
31	313·73	188·97	·57	42·345	203·363	+1·221
June 2	269·43	129·41	·58	42·091		
4	225·15	69·87	+0·59	41·836		

Greenwich Noon.	P.	L—O.	B.	Apparent Diameter. Equat. $2a$.	Defect.	Polar $2b$.	d.	Q.	B′.
1903.	°	°	°	″	″	″	°	°	°
June 6	334·687	215·571	+1·676	39·95	0·41	37·38	11·66	246·66	+1·79
8	334·677	215·790	1·693	40·20	0·41	37·61	11·70	246·68	1·81
10	334·668	215·998	1·710	40·45	0·42	37·84	11·73	246·70	1·83
12	334·660	216·196	1·727	40·71	0·42	38·08	11·75	246·72	1·85
14	334·653	216·384	1·743	40·97	0·43	38·32	11·75	246·75	1·86
16	334·646	216·559	1·759	41·23	0·43	38·57	11·75	246·77	1·88
18	334·640	216·725	1·774	41·49	0·43	38·82	11·73	246·80	1·89
20	334·635	216·877	1·789	41·76	0·43	39·07	11·71	246·83	1·91
22	334·629	217·020	1·804	42·03	0·43	39·32	11·67	246·86	1·93
24	334·624	217·150	1·819	42·31	0·43	39·58	11·62	246·89	1·94
26	334·620	217·268	1·833	42·59	0·42	39·84	11·55	246·93	1·96
28	334·617	217·373	1·847	42·86	0·42	40·10	11·48	246·97	1·97
30	334·614	217·466	1·860	43·14	0·42	40·36	11·39	247·01	1·99
July 2	334·611	217·547	1·873	43·42	0·41	40·62	11·29	247·05	2·00
4	334·608	217·615	1·885	43·70	0·41	40·88	11·18	247·10	2·02
6	334·606	217·671	1·897	43·98	0·41	41·15	11·05	247·14	2·03
8	334·604	217·714	1·909	44·26	0·40	41·42	10·92	247·19	2·04
10	334·602	217·744	1·920	44·54	0·39	41·68	10·77	247·24	2·05
12	334·601	217·761	1·931	44·82	0·38	41·94	10·60	247·30	2·06
14	334·601	217·765	1·941	45·10	0·37	42·20	10·43	247·36	2·07
16	334·600	217·756	1·951	45·38	0·36	42·46	10·24	247·42	2·08
18	334·601	217·734	1·960	45·66	0·35	42·72	10·03	247·49	2·09
20	334·601	217·698	1·969	45·94	0·33	42·98	9·82	247·56	2·10
22	334·602	217·650	1·977	46·21	0·32	43·23	9·59	247·63	2·11
24	334·604	217·589	1·985	46·48	0·30	43·48	9·35	247·71	2·12
26	334·606	217·515	1·992	46·74	0·29	43·73	9·09	247·79	2·13
28	334·608	217·428	1·999	47·00	0·28	43·97	8·82	247·88	2·13
30	334·611	217·329	2·005	47·25	0·26	44·21	8·54	247·98	2·14
Aug. 1	334·614	217·216	2·010	47·50	0·25	44·44	8·25	248·09	2·15
3	334·618	217·092	2·014	47·74	0·23	44·67	7·95	248·21	2·15
5	334·622	216·957	2·018	47·97	0·21	44·89	7·63	248·35	2·16
7	334·627	216·809	2·022	48·20	0·19	45·11	7·30	248·50	2·16
9	334·633	216·651	2·025	48·42	0·17	45·31	6·96	248·66	2·16
11	334·639	216·482	2·027	48·64	0·16	45·51	6·61	248·83	2·16
13	334·646	216·302	2·028	48·84	0·14	45·70	6·25	248·99	2·17
15	334·653	216·113	2·029	49·03	0·13	45·88	5·88	249·17	2·17
17	334·661	215·914	2·030	49·21	0·11	46·05	5·50	249·39	2·17
19	334·670	215·704	+2·029	49·38	0·10	46·20	5·11	249·68	+2·17

Greenwich Noon. 1903.	Longitude of ☽'s Central Meridian. 877°·90 I.	870°·27 II.	Corr. for Phase.	Light-time.	A—O.	B.
	°	°	°	m	°	°
June 6	180·88	10·34	+0·59	41·580		
8	136·62	310·82	·60	41·324		
10	92·36	251·31	·60	41·066	204·265	+1·265
12	48·12	191·81	·60	40·808		
14	3·89	132·32	·60	40·550		
16	319·67	72·83	·60	40·293		
18	275·46	13·34	·60	40·035		
20	231·26	313·89	·60	39·778	205·168	1·309
22	187·07	254·45	·59	39·522		
24	142·90	195·02	·59	39·267		
26	98·74	135·60	·58	39·013		
28	54·59	76·19	·57	38·761		
30	10·45	16·79	·56	38·510	206·071	1·352
July 2	326·32	317·40	·55	38·261		
4	282·21	258·01	·54	38·015		
6	238·10	198·64	·53	37·773		
8	194·00	139·28	·52	37·533		
10	149·91	79·93	·50	37·294	206·975	1·396
12	105·83	20·59	·49	37·059		
14	61·77	321·27	·47	36·831		
16	17·72	261·96	·46	36·605		
18	333·68	202·66	·44	36·382		
20	289·65	143·37	·42	36·164	207·881	1·439
22	245·62	84·09	·40	35·951		
24	201·61	24·81	·38	35·744		
26	157·61	325·55	·36	35·542		
28	113·61	266·29	·34	35·346		
30	69·62	207·04	·32	35·156	208·786	1·481
Aug. 1	25·65	147·80	·30	34·972		
3	341·69	88·58	·28	34·794		
5	297·73	29·36	·26	34·623		
7	253·78	330·14	·23	34·461		
9	209·84	270·93	·21	34·305	209·691	1·524
11	165·90	211·73	·19	34·156		
13	121·96	152·54	·17	34·015		
15	78·03	93·35	·15	33·883		
17	34·10	34·16	·13	33·758		
19	350·18	334·98	+0·11	33·642	210·598	+1·566

Greenwich Noon.	P.	L−O.	B.	Apparent Diameter. Equat. $2a$.	Defect.	Polar $2b$.	d.	Q.	B′.
1903.	°	°	°	″	″	″	°	°	°
Aug. 21	334·679	215·487	+2·028	49·54	0·09	46·34	4·71	249·98	+2·17
23	334·689	215·262	2·026	49·68	0·07	46·48	4·31	250·41	2·16
25	334·699	215·030	2·023	49·81	0·06	46·61	3·89	250·91	2·16
27	334·711	214·791	2·020	49·94	0·05	46·72	3·48	251·51	2·16
29	334·723	214·546	2·016	50·05	0·04	46·82	3·05	252·28	2·15
31	334·736	214·296	2·011	50·14	0·03	46·91	2·62	253·33	2·15
Sept. 2	334·749	214·042	2·006	50·22	0·02	46·98	2·19	254·78	2·14
4	334·763	213·782	2·000	50·28	0·01	47·04	1·75	256·86	2·14
6	334·777	213·521	1·994	50·33	0·01	47·08	1·33	260·29	2·13
8	334·792	213·257	1·987	50·36	0·00	47·11	0·90	266·98	2·13
10	334·807	212·992	1·980	50·37	0·00	47·13	0·51	284·84	2·12
12	334·824	212·726	1·972	50·38	0·00	47·13	0·31	346·28	2·11
14	334·842	212·460	1·964	50·36	0·00	47·11	0·59	35·35	2·10
16	334·860	212·195	1·955	50·34	0·01	47·09	1·00	48·97	2·09
18	334·878	211·932	1·946	50·30	0·01	47·05	1·42	54·62	2·08
20	334·895	211·672	1·937	50·24	0·01	47·00	1·87	57·61	2·07
22	334·913	211·415	1·927	50·17	0·02	46·93	2·30	59·45	2·06
24	334·931	211·161	1·916	50·08	0·03	46·85	2·73	60·74	2·05
26	334·949	210·913	1·905	49·97	0·04	46·76	3·15	61·68	2·04
28	334·969	210·670	1·894	49·86	0·05	46·65	3·58	62·41	2·03
30	334·989	210·434	1·882	49·73	0·06	46·53	3·99	62·96	2·01
Oct. 2	335·008	210·205	1·870	49·58	0·07	46·39	4·40	63·41	2·00
4	335·026	209·984	1·859	49·42	0·08	46·24	4·81	63·80	1·99
6	335·044	209·770	1·847	49·26	0·10	46·09	5·20	64·14	1·97
8	335·061	209·566	1·836	49·08	0·11	45·92	5·59	64·43	1·96
10	335·077	209·372	1·825	48·89	0·13	45·74	5·96	64·68	1·95
12	335·093	209·187	1·814	48·69	0·14	45·55	6·33	64·92	1·94
14	335·109	209·012	1·802	48·48	0·16	45·36	6·68	65·10	1·92
16	335·125	208·849	1·791	48·26	0·18	45·15	7·03	65·27	1·91
18	335·139	208·697	1·779	48·03	0·20	44·94	7·36	65·43	1·90
20	335·152	208·557	1·768	47·79	0·22	44·72	7·69	65·59	1·89
22	335·163	208·429	1·757	47·55	0·24	44·49	8·00	65·73	1·87
24	335·173	208·314	1·746	47·30	0·25	44·25	8·29	65·87	1·86
26	335·184	208·211	1·736	47·04	0·27	44·01	8·58	66·01	1·85
28	335·193	208·122	1·726	46·78	0·28	43·76	8·85	66·12	1·84
30	335·201	208·046	1·716	46·51	0·29	43·51	9·11	66·22	1·83
Nov. 1	335·207	207·983	1·707	46·24	0·31	43·25	9·35	66·31	1·82
3	335·212	207·934	+1·698	45·96	0·32	42·99	9·58	66·40	+1·81

Greenwich Noon.	Longitude of ♃'s Central Meridian. 877°·90 I.	870°·27 II.	Corr. for Phase.	Light-time.	A−O.	B.
1903.	°	°	°	m	°	°
Aug. 21	306·26	275·81	+0·10	33·535		
23	262·35	216·64	·08	33·437		
25	218·43	157·46	·06	33·348		
27	174·52	98·29	·05	33·267		
29	130·61	39·12	·04	33·196	211·505	+1·607
31	86·70	339·94	·03	33·137		
Sept. 2	42·79	280·77	·02	33·086		
4	358·87	221·59	·01	33·043		
6	314·95	162·41	+0·01	33·011		
8	271·03	103·23	·00	32·990	212·412	1·648
10	227·10	44·04	·00	32·978		
12	183·17	344·85	·00	32·975		
14	139·23	285·65	·00	32·983		
16	95·28	226·44	·00	33·001		
18	51·33	167·22	−0·01	33·029	213·321	1·689
20	7·37	108·00	·02	33·068		
22	323·40	48·77	·02	33·116		
24	279·41	349·53	·03	33·174		
26	235·42	290·28	·04	33·242		
28	191·41	231·01	·06	33·319	214·230	1·730
30	147·39	171·73	·07	33·405		
Oct. 2	103·36	112·44	·08	33·502		
4	59·32	53·14	·10	33·607		
6	15·26	353·83	·12	33·721		
8	331·19	294·50	·14	33·844	215·139	1·770
10	287·11	235·16	·16	33·976		
12	243·01	175·80	·17	34·117		
14	198·89	116·42	·19	34·266		
16	154·76	57·03	·21	34·423		
18	110·61	357·63	·24	34·586	216·050	1·809
20	66·45	298·21	·26	34·757		
22	22·27	238·76	·28	34·937		
24	338·07	179·30	·30	35·123		
26	293·85	119·83	·32	35·314		
28	249·62	60·34	·34	35·514	216·961	+1·848
30	205·37	0·83	·36	35·720		
Nov. 1	161·10	301·30	·38	35·931		
3	116·82	241·76	−0·40	36·147		

Greenwich Noon.	P.	L−O.	B.	Apparent Diameter. Equat. 2a.	Defect.	Polar 2b.	d.	Q.	B′.
1903.	°	°	°	″	″	″	°	°	°
Nov. 5	335·216	207·898	+1·689	45·68	0·34	42·73	9·80	66·48	+1·80
7	335·218	207·877	1·681	45·40	0·35	42·47	10·00	66·56	1·80
9	335·219	207·869	1·673	45·12	0·36	42·21	10·19	66·63	1·79
11	335·219	207·874	1·665	44·83	0·37	41·94	10·37	66·69	1·78
13	335·218	207·894	1·658	44·54	0·38	41·67	10·53	66·75	1·77
15	335·215	207·926	1·651	44·25	0·38	41·40	10·68	66·80	1·77
17	333·211	207·973	1·645	43·96	0·39	41·13	10·82	66·85	1·76
19	335·206	208·034	1·639	43·67	0·40	40·86	10·94	66·90	1·75
21	335·199	208·108	1·634	43·38	0·40	40·60	11·05	66·95	1·75
23	335·191	208·195	1·629	43·10	0·40	40·33	11·15	66·99	1·74
25	335·182	208·295	1·625	42·82	0·41	40·07	11·23	67·03	1·74
27	335·172	208·410	1·622	42·54	0·41	39·80	11·30	67·07	1·73
29	335·161	208·536	1·619	42·26	0·41	39·54	11·35	67·11	1·73
Dec. 1	335·148	208·675	1·616	41·98	0·41	39·28	11·40	67·14	1·73
3	335·134	208·827	1·614	41·70	0·41	39·02	11·43	67·17	1·72
5	335·120	208·991	1·612	41·43	0·41	38·76	11·45	67·20	1·72
7	335·104	209·167	1·611	41·16	0·41	38·51	11·45	67·22	1·72
9	335·088	209·354	1·610	40·90	0·41	38·26	11·45	67·25	1·72
11	335·071	209·553	1·610	40·64	0·40	38·01	11·43	67·27	1·72
13	335·053	209·764	1·611	40·38	0·40	37·77	11·40	67·30	1·72
15	335·035	209·987	1·612	40·12	0·40	37·53	11·36	67·32	1·72
17	335·017	210·220	1·613	39·87	0·40	37·30	11·31	67·34	1·72
19	334·999	210·464	1·615	39·62	0·39	37·07	11·25	67·35	1·73
21	334·980	210·719	1·618	39·38	0·38	36·84	11·18	67·37	1·73
23	334·960	210·984	1·621	39·14	0·37	36·62	11·10	67·38	1·73
25	334·939	211·259	1·625	38·91	0·36	36·40	11·00	67·40	1·74
27	334·918	211·543	1·629	38·68	0·35	36·19	10·90	67·41	1·74
29	334·897	211·838	1·634	38·46	0·34	35·98	10·79	67·43	1·75
31	334·876	212·141	1·639	38·24	0·33	35·78	10·67	67·45	1·75
1904.									
Jan. 2	334·856	212·453	1·644	38·03	0·32	35·58	10·54	67·46	1·76
4	334·836	212·774	1·650	37·82	0·31	35·38	10·40	67·48	1·77
6	334·816	213·102	1·656	37·62	0·30	35·19	10·26	67·50	1·77
8	334·796	213·440	1·663	37·42	0·29	35·00	10·10	67·52	1·78
10	334·775	213·785	1·670	37·22	0·28	34·82	9·94	67·54	1·79
12	334·755	214·137	1·678	37·03	0·27	34·64	9·77	67·56	1·80
14	334·737	214·498	1·686	36·85	0·26	34·47	9·59	67·58	1·80
16	334·719	214·866	1·694	36·67	0·25	34·31	9·41	67·61	1·81
18	334·701	215·240	+1·703	36·50	0·24	34·15	9·22	67·63	+1·82

Greenwich Noon.	Longitude of ℳ's Central Meridian. 877°·90 I.	870°·27 II.	Corr. for Phase.	Light-time.	A−O.	B
1903.	°	°	°	m	°	°
Nov. 5	72·52	182·20	−·42	36·368		
7	28·20	122·63	·44	36·594	217·872	+1·887
9	343·87	63·04	·45	36·824		
11	299·52	3·43	·47	37·058		
13	255·16	303·81	·48	37·296		
15	210·78	244·17	·50	37·539		
17	166·38	184·51	·51	37·785	218·783	1·925
19	121·97	124·84	·52	38·034		
21	77·54	65·15	·53	38·286		
23	33·10	5·45	·54	38·540		
25	348·64	305·73	·55	38·796		
27	304·17	246·00	·55	39·055	219·695	1·963
29	259·69	186·26	·56	39·314		
Dec. 1	215·19	126·51	·56	39·574		
3	170·68	66·74	·57	39·836		
5	126·16	6·96	·57	40·097		
7	81·63	307·16	·57	40·359	220·608	2·000
9	37·08	247·35	·57	40·621		
11	352·52	187·53	·57	40·883		
13	307·95	127·71	·56	41·146		
15	263·37	67·87	·56	41·407		
17	218·77	8·02	·55	41·667	221·522	+2·037
19	174·17	308·16	·55	41·926		
21	129·56	248·29	·54	42·183		
23	84·94	188·41	·54	42·439		
25	40·31	128·52	·53	42·694		
27	355·67	68·62	·52	42·946	222·434	2·074
29	311·02	8·71	·51	43·196		
31	266·36	308·80	·49	43·443		
1904.						
Jan. 2	221·70	248·88	·48	43·688		
4	177·03	188·96	·47	43·929		
6	132·36	129·03	·46	44·166	223·347	2·109
8	87·68	69·09	·44	44·400		
10	43·00	9·14	·43	44·632		
12	358·31	309·19	·42	44·859		
14	313·62	249·24	·40	45·083		
16	268·92	189·28	·38	45·303	224·262	+2·145
18	224·21	129·31	−·37	45·518		

Greenwich Noon.	P.	L−O.	B.	Apparent Diameter. Equat. $2a$.	Defect.	Polar $2b$.	d.	Q.	B′.
1904.	°	°	°	″	″	″	°	°	°
Jan. 20	334·684	215·622	+1·712	36·33	0·22	33·99	9·02	67·66	+1·83
22	334·668	216·010	1·721	36·17	0·21	33·84	8·81	67·69	1·84
24	334·653	216·404	1·731	36·01	0·20	33·69	8·60	67·73	1·85
26	334·639	216·804	1·741	35·85	0·19	33·55	8·38	67·77	1·86
28	334·625	217·210	1·751	35·70	0·18	33·41	8·16	67·81	1·87
30	334·612	217·621	1·762	35·55	0·17	33·28	7·93	67·86	1·88
Feb. 1	334·600	218·038	1·773	35·41	0·16	33·15	7·70	67·91	1·89
3	334·589	218·460	1·784	35·29	0·15	33·02	7·46	67·97	1·91
5	334·580	218·886	1·796	35·16	0·14	32·90	7·21	68·03	1·92
7	334·572	219·318	1·808	35·04	0·13	32·79	6·97	68·10	1·93
9	334·565	219·753	1·820	34·93	0·12	32·68	6·72	68·17	1·94
11	334·559	220·192	1·832	34·82	0·11	32·57	6·46	68·25	1·96
13	334·555	220·637	1·845	34·71	0·10	32·47	6·20	68·33	1·97
15	334·552	221·084	1·858	34·61	0·09	32·38	5·93	68·42	1·99
17	334·550	221·536	1·871	34·51	0·08	32·29	5·66	68·52	2·00
19	334·549	221·991	1·884	34·42	0·07	32·20	5·39	68·62	2·01
21	334·549	222·449	1·898	34·33	0·06	32·12	5·12	68·73	2·02
23	334·550	222·909	+1·912	34·25	0·06	32·04	4·84	68·84	+2·04

The following is a list of the Greenwich Mean Times when the Zero Meridians of the two adopted systems cross the centre of the illuminated disc :—

System I.

1903.	d	h	m	1903.	d	h	m	1903.	d	h	m	1903.	d	h	m
Mar.	28	1	44·67	Apr.	3	5	24·01	Apr.	9	9	3·15	Apr.	15	12	42·17
		11	35·30			15	14·62			18	53·76			22	32·76
		21	25·93		4	1	5·23		10	4	44·37		16	8	23·35
	29	7	16·56			10	55·84			14	34·97			18	13·94
		17	7·19			20	46·45		11	0	25·58		17	4	4·54
	30	2	57·82		5	6	37·06			10	16·18			13	55·14
		12	48·44			16	27·67			20	6·79			23	45·74
		22	39·06		6	2	18·27		12	5	57·39		18	9	36·34
	31	8	29·68			12	8·88			15	47·99			19	26·93
		18	20·30			21	59·48		13	1	38·59		19	5	17·53
Apr.	1	4	10·92		7	7	50·09			11	29·19			15	8·12
		14	1·54			17	40·70			21	19·79		20	0	58·71
		23	52·16		8	3	31·32		14	7	10·39			10	49·31
	2	9	42·78			13	21·93			17	0·98			20	39·90
		19	33·39			23	12·54		15	2	51·58		21	6	30·50

Greenwich Noon.	Longitude of ♃'s Central Meridian. 877°·90. I.	870°·27 II.	Corr. for Phase.	Light-time.	A−O.	B.
1904.	°	°	°	m	°	°
Jan. 20	179·50	69·34	−·35	45·729		
22	134·78	9·37	·34	45·936		
24	90·06	309·39	·32	46·138		
26	45·34	249·41	·30	46·334	225·175	+2·179
28	0·62	189·43	·29	46·525		
30	315·90	129·44	·28	46·712		
Feb. 1	271·17	69·46	·26	46·893		
3	226·44	9·47	·24	47·068		
5	181·71	309·48	·23	47·238	226·089	2·213
7	136·98	249·49	·21	47·404		
9	92·24	189·50	·19	47·563		
11	47·51	129·51	·18	47·716		
13	2·78	69·52	·17	47·863		
15	318·05	9·53	·15	48·005	227·005	+2·247
17	273·31	309·53	·14	48·140		
19	228·58	249·54	·13	48·269		
21	183·84	189·54	·11	48·391		
23	139·10	129·54	−0·10	48·506		

System I.

1903.	d	h	m	1903.	d	h	m	1903.	d	h	m	1903.	d	h	m
Apr.	21	16	21·09	Apr.	29	1	31·63	May	6	10	41·97	May	13	19	52·10
	22	2	11·68			11	22·21			20	32·53		14	5	42·66
		12	2·27			21	12·79		7	6	23·10			15	33·21
		21	52·86		30	7	3·37			16	13·67		15	1	23·77
	23	7	43·45			16	53·95		8	2	4·23			11	14·32
		17	34·04	May	1	2	44·53			11	54·80			21	4·88
	24	3	24·63			12	35·11			21	45·36		16	6	55·44
		13	15·21			22	25·68		9	7	35·93			16	45·99
		23	5·80		2	8	16·26			17	26·49		17	2	36·55
	25	8	56·38			18	6·83		10	3	17·06			12	27·11
		18	46·97		3	3	57·41			13	7·62			22	17·66
	26	4	37·55			13	47·98			22	58·18		18	8	8·21
		14	28·14			23	38·55		11	8	48·74			17	58·76
	27	0	18·72		4	9	29·12			18	39·30		19	3	49·31
		10	9·31			19	19·69		12	4	29·86			13	39·86
		19	59·89		5	5	10·26			14	20·42			23	30·41
	28	5	50·47			15	0·83		13	0	10·98		20	9	20·96
		15	41·05		6	0	51·40			10	1·54			19	11·50

System I.

1903.	d	h	m	1903.	d	h	m	1903.	d	h	m	1903.	d	h	m
May	21	5	2·05	June	5	19	2·33	June	21	9	1·67	July	6	23	0·01
		14	52·60		6	4	52·85			18	52·17		7	8	50·48
	22	0	43·14			14	43·37		22	4	42·66			18	40·95
		10	33·69		7	0	33·89			14	33·16		8	4	31·42
		20	24·23			10	24·41		23	0	23·65			14	21·88
	23	6	14·77			20	14·93			10	14·15		9	0	12·35
		16	5·31		8	6	5·45			20	4·64			10	2·81
	24	1	55·85			15	55·97		24	5	55·13			19	53·28
		11	46·39		9	1	46·49			15	45·62		10	5	43·74
		21	36·93			11	37·01		25	1	36·11			15	34·21
	25	7	27·47			21	27·52			11	26·60		11	1	24·67
		17	18·00		10	7	18·04			21	17·09			11	15·14
	26	3	8·54			17	8·56		26	7	7·58			21	5·60
		12	59·08		11	2	59·07			16	58·07		12	6	56·06
		22	49·61			12	49·58		27	2	48·56			16	46·52
	27	8	40·15			22	40·09			12	39·04		13	2	36·98
		18	30·69		12	8	30·60			22	29·53			12	27·44
	28	4	21·23			18	21·11		28	8	20·02			22	17·90
		14	11·77		13	4	11·62			18	10·50		14	8	8·36
	29	0	2·31			14	2·13		29	4	0·99			17	58·81
		9	52·85			23	52·64			13	51·47		15	3	49·27
		19	43·38		14	9	43·15			23	41·95			13	39·73
	30	5	33·92			19	33·65		30	9	32·43			23	30·18
		15	24·45		15	5	24·16			19	22·91		16	9	20·64
	31	1	14·98			15	14·67	July	1	5	13·39			19	11·10
		11	5·51		16	1	5·17			15	3·87		17	5	1·55
		20	56·04			10	55·68		2	0	54·35			14	52·00
June	1	6	46·57			20	46·18			10	44·82		18	0	42·46
		16	37·10		17	6	36·68			20	35·30			10	32·91
	2	2	27·63			16	27·19		3	6	25·78			20	23·36
		12	18·15		18	2	17·69			16	16·25		19	6	13·81
		22	8·68			12	8·19		4	2	6·72			16	4·26
	3	7	59·21			21	58·69			11	57·19		20	1	54·71
		17	49·73		19	7	49·19			21	47·66			11	45·16
	4	3	40·25			17	39·69		5	7	38·13			21	35·61
		13	30·77		20	3	30·18			17	28·60		21	7	26·05
		23	21·29			13	20·68		6	3	19·07			17	16·50
	5	9	11·81			23	11·18			13	9·54		22	3	6·94

System I.

1903.	d	h	m
July	22	12	57·39
		22	47·83
	23	8	38·27
		18	28·71
	24	4	19·15
		14	9·59
	25	0	0·03
		9	50·47
		19	40·91
	26	5	31·35
		15	21·79
	27	1	12·23
		11	2·67
		20	53·11
	28	6	43·55
		16	33·99
	29	2	24·43
		12	14·86
		22	5·30
	30	7	55·73
		17	46·16
	31	3	36·59
		13	27·02
		23	17·45
Aug.	1	9	7·88
		18	58·31
	2	4	48·74
		14	39·16
	3	0	29·59
		10	20·01
		20	10·43
	4	6	0·85
		15	51·27
	5	1	41·70
		11	32·13
		21	22·56
	6	7	12·98
		17	3·41

1903.	d	h	m
Aug.	7	2	53·84
		12	44·26
		22	34·69
	8	8	25·11
		18	15·54
	9	4	5·96
		13	56·38
		23	46·80
	10	9	37·22
		19	27·64
	11	5	18·05
		15	8·47
	12	0	58·89
		10	49·30
		20	39·72
	13	6	30·13
		16	20·54
	14	2	10·96
		12	1·37
		21	51·78
	15	7	42·20
		17	32·61
	16	3	23·03
		13	13·44
		23	3·86
	17	8	54·27
		18	44·69
	18	4	35·10
		14	25·52
	19	0	15·93
		10	6·34
		19	56·76
	20	5	47·17
		15	37·58
	21	1	27·99
		11	18·40
		21	8·81
	22	6	59·22

1903.	d	h	m
Aug.	22	16	49·63
	23	2	40·04
		12	30·45
		22	20·86
	24	8	11·26
		18	1·67
	25	3	52·08
		13	42·49
		23	32·90
	26	9	23·31
		19	13·72
	27	5	4·13
		14	54·54
	28	0	44·95
		10	35·36
		20	25·77
	29	6	16·18
		16	6·59
	30	1	56·99
		11	47·40
		21	37·80
	31	7	28·21
		17	18·61
Sept.	1	3	9·02
		12	59·42
		22	49·82
	2	8	40·23
		18	30·63
	3	4	21·03
		14	11·44
	4	0	1·84
		9	52·24
		19	42·65
	5	5	33·06
		15	23·47
	6	1	13·88
		11	4·29
		20	54·69

1903.	d	h	m
Sept.	7	6	45·10
		16	35·51
	8	2	25·92
		12	16·33
		22	6·74
	9	7	57·15
		17	47·56
	10	3	37·97
		13	28·38
		23	18·79
	11	9	9·20
		18	59·61
	12	4	50·02
		14	40·43
	13	0	30·84
		10	21·25
		20	11·66
	14	6	2·07
		15	52·48
	15	1	42·90
		11	33·31
		21	23·73
	16	7	14·15
		17	4·57
	17	2	54·99
		12	45·41
		22	35·83
	18	8	26·25
		18	16·67
	19	4	7·10
		13	57·52
		23	47·95
	20	9	38·37
		19	28·80
	21	5	19·22
		15	9·65
	22	1	0·07
		10	50·50

System I.

1903.	d	h	m	1903.	d	h	m	1903.	d	h	m	1903.	d	h	m
Sept.	22	20	40·93	Oct.	8	10	37·95	Oct.	24	0	36·46	Nov.	8	14	36·63
	23	6	31·36			20	28·42			10	26·97		9	0	27·18
		16	21·79		9	6	18·89			20	17·48			10	17·74
	24	2	12·22			16	9·36		25	6	7·99			20	8·29
		12	2·65		10	1	59·83			15	58·51		10	5	58·84
		21	53·09			11	50·30		26	1	49·02			15	49·40
	25	7	43·52			21	40·77			11	39·54		11	1	39·96
		17	33·96		11	7	31·24			21	30·06			11	30·52
	26	3	24·40			17	21·71		27	7	20·58			21	21·08
		13	14·84		12	3	12·18			17	11·10		12	7	11·64
		23	5·28			13	2·66		28	3	1·62			17	2·20
	27	8	55·72			22	53·13			12	52·14		13	2	52·77
		18	46·16		13	8	43·61			22	42·66			12	43·33
	28	4	36·60			18	34·09		29	8	33·19			22	33·89
		14	27·04		14	4	24·57			18	23·71		14	8	24·46
	29	0	17·49			14	15·05		30	4	14·24			18	15·02
		10	7·93		15	0	5·54			14	4·76		15	4	5·59
		19	58·38			9	56·02			23	55·29			13	56·16
	30	5	48·83			19	46·51		31	9	45·82			23	46·73
		15	39·27		16	5	37·00			19	36·35		16	9	37·30
Oct.	1	1	29·72			15	27·49	Nov.	1	5	26·88			19	27·87
		11	20·17		17	1	17·98			15	17·42		17	5	18·44
		21	10·62			11	8·47		2	1	7·95			15	9·01
	2	7	1·07			20	58·96			10	58·49		18	0	59·59
		16	51·52		18	6	49·45			20	49·03			10	50·17
	3	2	41·97			16	39·94		3	6	39·56			20	40·75
		12	32·42		19	2	30·44			16	30·10		19	6	31·33
		22	22·87			12	20·94		4	2	20·64			16	21·91
	4	8	13·33			22	11·44			12	11·18		20	2	12·49
		18	3·79		20	8	1·94			22	1·72			12	3·07
	5	3	54·25			17	52·43		5	7	52·26			21	53·65
		13	44·71		21	3	42·93			17	42·80		21	7	44·24
		23	35·17			13	33·43		6	3	33·34			17	34·82
	6	9	25·63			23	23·93			13	23·89		22	3	25·41
		19	16·09		22	9	14·44			23	14·43			13	16·00
	7	5	6·55			19	4·94		7	9	4·98			23	6·59
		14	57·02		23	4	55·45			18	55·53		23	8	57·17
	8	0	47·48			14	45·95		8	4	46·08			18	47·76

System I.

1903.	d	h	m
Nov.	24	4	38·34
		14	28·93
	25	0	19·52
		10	10·11
		20	0·70
	26	5	51·29
		15	41·89
	27	1	32·48
		11	23·08
		21	13·67
	28	7	4·27
		16	54·87
	29	2	45·47
		12	36·08
		22	26·68
	30	8	17·28
		18	7·88
Dec.	1	3	58·48
		13	49·09
		23	39·70
	2	9	30·31
		19	20·92
	3	5	11·53
		15	2·14
	4	0	52·75
		10	43·36
		20	33·97
	5	6	24·58
		16	15·19
	6	2	5·80
		11	56·41
		21	47·03
	7	7	37·64
		17	28·25
	8	3	18·87
		13	9·49
		23	0·10
	9	8	50·72

1903.	d	h	m
Dec.	9	18	41·34
	10	4	31·96
		14	22·58
	11	0	13·20
		10	3·82
		19	54·44
	12	5	45·06
		15	35·68
	13	1	26·31
		11	16·93
		21	7·56
	14	6	58·18
		16	48·81
	15	2	39·44
		12	30·07
		22	20·70
	16	8	11·33
		18	1·96
	17	3	52·59
		13	43·22
		23	33·86
	18	9	24·49
		19	15·13
	19	5	5·76
		14	56·40
	20	0	47·04
		10	37·68
		20	28·32
	21	6	18·96
		16	9·60
	22	2	0·24
		11	50·88
		21	41·53
	23	7	32·17
		17	22·81
	24	3	13·45
		13	4·10
		22	54·74

1903.	d	h	m
Dec.	25	8	45·38
		18	36·03
	26	4	26·67
		14	17·32
	27	0	7·97
		9	58·61
		19	49·26
	28	5	39·91
		15	30·55
	29	1	21·20
		11	11·85
		21	2·50
	30	6	53·15
		16	43·80
	31	2	34·45
		12	25·10
		22	15·75
1904. Jan.	1	8	6·40
		17	57·05
	2	3	47·70
		13	38·35
		23	29·00
	3	9	19·66
		19	10·31
	4	5	0·96
		14	51·62
	5	0	42·27
		10	32·93
		20	23·58
	6	6	14·24
		16	4·90
	7	1	55·56
		11	46·21
		21	36·87
	8	7	27·52
		17	18·18
	9	3	8·84

1904.	d	h	m
Jan.	9	12	59·50
		22	50·16
	10	8	40·82
		18	31·48
	11	4	22·14
		14	12·80
	12	0	3·46
		9	54·12
		19	44·78
	13	5	35·44
		15	26·10
	14	1	16·76
		11	7·43
		20	58·09
	15	6	48·75
		16	39·42
	16	2	30·08
		12	20·74
		22	11·41
	17	8	2·07
		17	52·74
	18	3	43·41
		13	34·07
		23	24·74
	19	9	15·41
		19	6·08
	20	4	56·74
		14	47·41
	21	0	38·08
		10	28·75
		20	19·42
	22	6	10·09
		16	0·76
	23	1	51·42
		11	42·09
		21	32·76
	24	7	23·42
		17	14·09

System I.

1904.	d	h	m	1904.	d	h	m	1904.	d	h	m	1904.	d	h	m
Jan.	25	3	4·76	Feb.	1	22	7·51	Feb.	9	7	19·63	Feb.	16	16	31·79
		12	55·43		2	7	58·18			17	10·31		17	2	22·47
		22	46·10			17	48·85		10	3	0·99			12	13·14
	26	8	36·77		3	3	39·52			12	51·66			22	3·82
		18	27·44			13	30·19			22	42·34		18	7	54·49
	27	4	18·11			23	20·87		11	8	33·02			17	45·17
		14	8·78		4	9	11·54			18	23·69		19	3	35·84
		23	59·45			19	2·21		12	4	14·37			13	26·52
	28	9	50·12		5	4	52·89			14	5 04			23	17·19
		19	40·79			14	43·56			23	55·72		20	9	7·87
	29	5	31·46		6	0	34·23		13	9	46·39			18	58·54
		15	22·13			10	24·90			19	37·07		21	4	49·22
	30	1	12·80			20	15·58		14	5	27·74			14	39·89
		11	3·47		7	6	6·25			15	18·42		22	0	30·57
		20	54·15			15	56·93		15	1	9·09			10	21·24
	31	6	44·82		8	1	47·60			10	59·77			20	11·92
		16	35·49			11	38·28			20	50·44		23	6	2·59
Feb.	1	2	26·17			21	28·96		16	6	41·12			15	53·27
		12	16·84												

System II.

1903.	d	h	m	1903.	d	h	m	1903.	d	h	m	1903.	d	h	m
Mar.	28	1	39·63	Apr.	4	2	28·21	Apr.	11	3	16·64	Apr.	18	4	4·84
		11	35·43			12	24·00			13	12·42			14	0·62
		21	31·24			22	19·79			23	8·21			23	56·40
	29	7	27·04		5	8	15·58		12	9	3·99		19	9	52·17
		17	22·84			18	11·37			18	59·77			19	47·95
	30	3	18·64		6	4	7·16		13	4	55·55		20	5	43·72
		13	14·44			14	2·95			14	51·33			15	39·50
		23	10·24			23	58·74		14	0	47·11		21	1	35·27
	31	9	6 04		7	9	54·53			10	42·89			11	31·04
		19	1·84			19	50·32			20	38·66			21	26·81
Apr.	1	4	57·64		8	5	46·12		15	6	34·44		22	7	22·58
		14	53·44			15	41·91			16	30·21			17	18·35
	2	0	49·23		9	1	37·70		16	2	25·98		23	3	14·12
		10	45·03			11	33·49			12	21·75			13	9·88
		20	40·82			21	29·28			22	17·52			23	5·65
	3	6	36·62		10	7	25·07		17	8	13·29		24	9	1·42
		16	32·41			17	20·86			18	9·07			18	57·18

System II.

1903.	d	h	m	1903.	d	h	m	1903.	d	h	m	1903.	d	h	m
Apr.	25	4	52·95	May	10	22	11·53	May	26	15	29·21	June	11	8	45·94
		14	48·71		11	8	7·27		27	1	24·92			18	41·63
	26	0	44·47			18	2·01			11	20·63		12	4	37·32
		10	40·23		12	3	58·75			21	16·35			14	33·01
		20	35·99			13	54·49		28	7	12·06		13	0	28·70
	27	6	31·75			23	50·22			17	7·77			10	24·39
		16	27·52		13	9	45·96		29	3	3·48			20	20·07
	28	2	23·28			19	41·70			12	59·19		14	6	15·76
		12	19·04		14	5	37·43			22	54·90			16	11·45
		22	14·80			15	33·17		30	8	50·61		15	2	7·13
	29	8	10·56		15	1	28·90			18	46·32			12	2·81
		18	6·32			11	24·64		31	4	42·03			21	58·50
	30	4	2·08			21	20·37			14	37·74		16	7	54·18
		13	57·84		16	7	16·10	June	1	0	33·45			17	49·86
		23	53·59			17	11·84			10	29·16		17	3	45·55
May	1	9	49·35		17	3	7·57			20	24·86			13	41·23
		19	45·11			13	3·30		2	6	20·57			23	36·91
	2	5	40·86			22	59·04			16	16·28		18	9	32·59
		15	36·61		18	8	54·77		3	2	11·98			19	28·27
	3	1	32·36			18	50·50			12	7·69		19	5	23·95
		11	28·11		19	4	46·23			22	3·39			15	19·63
		21	23·86			14	41·96		4	7	59·10		20	1	15·30
	4	7	19·61		20	0	37·69			17	54·80			11	10·98
		17	15·36			10	33·41		5	3	50·50			21	6·65
	5	3	11·11			20	29·14			13	46·21		21	7	2·33
		13	6·86		21	6	24·86			23	41·91			16	58·00
		23	2·60			16	20·59		6	9	37·61		22	2	53·67
	6	8	58·34		22	2	16·31			19	33·31			12	49·34
		18	54·09			12	12·03		7	5	29·00			22	45·01
	7	4	49·83			22	7·75			15	24·70		23	8	40·68
		14	45·58		23	8	3·47		8	1	20·40			18	36·35
	8	0	41·32			17	59·19			11	16·09		24	4	32·02
		10	37·07		24	3	54·91			21	11·79			14	27·68
		20	32·81			13	50·63		9	7	7·48		25	0	23·35
	9	6	28·56			23	46·35			17	3·18			10	19·01
		16	24·30		25	9	42·06		10	2	58·87			20	14·68
	10	2	20·04			19	37·78			12	54·56		26	6	10·34
		12	15·79		26	5	33·49			22	50·25			16	6·00

System II.

1903.	d	h	m
June	27	2	1·67
		11	57·33
		21	52·99
	28	7	48·66
		17	44·32
	29	3	39·98
		13	35·64
		23	31·30
	30	9	26·96
		19	22·62
July	1	5	18·28
		15	13·94
	2	1	9·59
		11	5·25
		21	0·90
	3	6	56·56
		16	52·21
	4	2	47·86
		12	43·51
		22	39·16
	5	8	34·81
		18	30·46
	6	4	26·11
		14	21·76
	7	0	17·41
		10	13·06
		20	8·71
	8	6	4·35
		16	0·00
	9	1	55·64
		11	51·29
		21	46·93
	10	7	42·57
		17	38·21
	11	3	33·85
		13	29·49
		23	25·12
	12	9	20·76

1903.	d	h	m
July	12	19	16·40
	13	5	12·03
		15	7·67
	14	1	3·30
		10	58·93
		20	54·56
	15	6	50·19
		16	45·82
	16	2	41·45
		12	37·08
		22	32·71
	17	8	28·34
		18	23·97
	18	4	19·59
		14	15·22
	19	0	10·85
		10	6·47
		20	2·10
	20	5	57·72
		15	53·35
	21	1	48·97
		11	44·59
		21	40·22
	22	7	35·84
		17	31·46
	23	3	27·08
		13	22·70
		23	18·32
	24	9	13·93
		19	9·55
	25	5	5·17
		15	0·78
	26	0	56·40
		10	52·02
		20	47·63
	27	6	43·25
		16	38·87
	28	2	34·48

1903.	d	h	m
July	28	12	30·10
		22	25·71
	29	8	21·32
		18	16·93
	30	4	12·54
		14	8·15
	31	0	3·76
		9	59·37
		19	54·97
Aug.	1	5	50·58
		15	46·18
	2	1	41·79
		11	37·39
		21	32·99
	3	7	28·59
		17	24·19
	4	3	19·79
		13	15·39
		23	10·99
	5	9	6·60
		19	2·21
	6	4	57·81
		14	53·41
	7	0	49·02
		10	44·62
		20	40·22
	8	6	35·82
		16	31·42
	9	2	27·02
		12	22·62
		22	18·21
	10	8	13·81
		18	9·40
	11	4	5·00
		14	0·59
		23	56·18
	12	9	51·78
		19	47·37

1903.	d	h	m
Aug.	13	5	42·96
		15	38·55
	14	1	34·14
		11	29·73
		21	25·31
	15	7	20·90
		17	16·49
	16	3	12·09
		13	7·68
		23	3·27
	17	8	58·86
		18	54·45
	18	4	50·04
		14	45·63
	19	0	41·22
		10	36·81
		20	32·39
	20	6	27·98
		16	23·57
	21	2	19·15
		12	14·74
		22	10·32
	22	8	5·91
		18	1·49
	23	3	56·07
		13	52·66
		23	48·24
	24	9	43·82
		19	39·40
	25	5	34·98
		15	30·57
	26	1	26·15
		11	21·74
		21	17·32
	27	7	12·91
		17	8·49
	28	3	4·07
		12	59·66

System II.

1903.	d	h	m
Aug.	28	22	55·24
	29	8	50·82
		18	46·41
	30	4	41·99
		14	37·57
	31	0	33·16
		10	28·74
		20	24·32
Sept.	1	6	19·90
		16	15·48
	2	2	11·06
		12	6·64
		22	2·22
	3	7	57·80
		17	53·39
	4	3	48·97
		13	44·55
		23	40·14
	5	9	35·72
		19	31·31
	6	5	26·89
		15	22·48
	7	1	18·06
		11	13·65
		21	9·23
	8	7	4·82
		17	0·40
	9	2	55·99
		12	51·57
		22	47·16
	10	8	42·74
		18	38·33
	11	4	33·91
		14	29·50
	12	0	25·08
		10	20·67
		20	16·25
	13	6	11·84

1903.	d	h	m
Sept.	13	16	7·42
	14	2	3·01
		11	58·60
		21	54·19
	15	7	49·78
		17	45·37
	16	3	40·97
		13	36·56
		23	32·16
	17	9	27·75
		19	23·35
	18	5	18·95
		15	14·54
	19	1	10·14
		11	5·74
		21	1·34
	20	6	56·94
		16	52·54
	21	2	48·14
		12	43·74
		22	39·34
	22	8	34·95
		18	30·55
	23	4	26·16
		14	21·76
	24	0	17·37
		10	12·98
		20	8·59
	25	6	4·20
		15	59·81
	26	1	55·42
		11	51·03
		21	46·65
	27	7	42·26
		17	37·88
	28	3	33·50
		13	29·11
		23	24·73

1903.	d	h	m
Sept.	29	9	20·35
		19	15·98
	30	5	11·60
		15	7·22
Oct.	1	1	2·85
		10	58·47
		20	54·10
	2	6	49·72
		16	45·35
	3	2	40·98
		12	36·61
		22	32·24
	4	8	27·87
		18	23·51
	5	4	19·14
		14	14·78
	6	0	10·42
		10	6·05
		20	1·69
	7	5	57·33
		15	52·97
	8	1	48·61
		11	44·25
		21	39·90
	9	7	35·54
		17	31·19
	10	3	26·83
		13	22·48
		23	18·13
	11	9	13·77
		19	9·42
	12	5	5·07
		15	0·73
	13	0	56·38
		10	52·03
		20	47·69
	14	6	43·34
		16	39·00

1903.	d	h	m
Oct.	15	2	34·66
		12	30·32
		22	25·98
	16	8	21·65
		18	17·31
	17	4	12·98
		14	8·65
	18	0	4·32
		9	59·99
		19	55·66
	19	5	51·33
		15	47·01
	20	1	42·68
		11	38·36
		21	34·04
	21	7	29·71
		17	25·39
	22	3	21·07
		13	16·76
		23	12·44
	23	9	8·13
		19	3·81
	24	4	59·50
		14	55·19
	25	0	50·87
		10	46·56
		20	42·25
	26	6	37·95
		16	33·64
	27	2	29·33
		12	25·03
		22	20·72
	28	8	16·42
		18	12·12
	29	4	7·82
		14	3·52
		23	59·23
	30	9	54·93

System II.

1903.	d	h	m	1903.	d	h	m	1903.	d	h	m	1903.	d	h	m
Oct.	30	19	50·64	Nov.	15	13	8·24	Dec.	1	6	27·35	Dec.	16	23	47·62
	31	5	46·34			23	3·99			16	23·13		17	9	43·43
		15	42·05		16	8	59·74		2	2	18·92			19	39·24
Nov.	1	1	37·76			18	55·49			12	14·71		18	5	35·05
		11	33·47		17	4	51·24			22	10·49			15	30·87
		21	29·18			14	46·99		3	8	6·28		19	1	26·68
	2	7	24·89		18	0	42·74			18	2·07			11	22·50
		17	20·61			10	38·50		4	3	57·85			21	18·32
	3	3	16·32			20	34·25			13	53·64		20	7	14·13
		13	12·04		19	6	30·01			23	49·43			17	9·95
		23	7·75			16	25·77		5	9	45·21		21	3	5·77
	4	9	3·47		20	2	21·53			19	41·00			13	1·60
		18	59·19			12	17·29		6	5	36·79			22	57·42
	5	4	54·91			22	13·05			15	32·59		22	8	53·24
		14	50·63		21	8	8·82		7	1	28·38			18	49·07
	6	0	46·35			18	4·58			11	24·17		23	4	44·89
		10	42·08		22	4	0·35			21	19·97			14	40·71
		20	37·80			13	56·11		8	7	15·76		24	0	36·53
	7	6	33·53			23	51·88			17	11·56			10	32·35
		16	29·25		23	9	47·64		9	3	7·35			20	28·17
	8	2	24·98			19	43·41			13	3·15		25	6	24·00
		12	20·71		24	5	39·17			22	58·95			16	19·82
		22	16·43			15	34·94		10	8	54·75		26	2	15·64
	9	8	12·16		25	1	30·71			18	50·55			12	11·47
		18	7·89			11	26·48		11	4	46·35			22	7·29
	10	4	3·63			21	22·25			14	42·16		27	8	3·12
		13	59·36		26	7	18·02		12	0	37·96			17	58·94
		23	55·09			17	13·80			10	33·76		28	3	54·77
	11	9	50·83		27	3	9·57			20	29·57			13	50·60
		19	46·56			13	5·34		13	6	25·37			23	46·42
	12	5	42·30			23	1·12			16	21·17		29	9	42·25
		15	38·04		28	8	56·89		14	2	16·98			19	38·08
	13	1	33·78			18	52·67			12	12·78		30	5	33·90
		11	29·52		29	4	48·45			22	8·58			15	29·73
		21	25·27			14	44·23		15	8	4·39		31	1	25·56
	14	7	21·01		30	0	40·01			18	0·19			11	21·39
		17	16·75			10	35·79		16	3	56·00			21	17·22
	15	3	12·50			20	31·57			13	51·81				

System II.

1904.	d	h	m	1904.	d	h	m	1904.	d	h	m	1904.	d	h	m
Jan.	1	7	13·05	Jan.	14	22	55·67	Jan.	28	14	38·63	Feb.	10	20	25·93
		17	8·88		15	8	51·52		29	0	34·48		11	6	21·79
	2	3	4·71			18	47·36			10	30·34			16	17·64
		13	0·54		16	4	43·20			20	26·19		12	2	13·50
		22	56·37			14	39·05		30	6	22·04			12	9·35
	3	8	52·20		17	0	34·89			16	17·90			22	5·21
		18	48·03			10	30·74		31	2	13·75		13	8	1·06
	4	4	43·87			20	26·58			12	9·60			17	56·92
		14	39·70		18	6	22·43			22	5·46		14	3	52·78
	5	0	35·53			16	18·28	Feb.	1	8	1·31			13	48·63
		10	31·37		19	2	14·12			17	57·16			23	44·49
		20	27·20			12	9·97		2	3	53·01		15	9	40·35
	6	6	23·04			22	5·82			13	48·86			19	36·20
		16	18·87		20	8	1·66			23	44·71		16	5	32·06
	7	2	14·71			17	57·51		3	9	40·56			15	27·91
		12	10·55		21	3	53·36			19	36·41		17	1	23·77
		22	6·38			13	49·21		4	5	32·26			11	19·62
	8	8	2·22			23	45·06			15	28·12			21	15·48
		17	58·06		22	9	40·90		5	1	23·97		18	7	11·33
	9	3	53·90			19	36·75			11	19·82			17	7·19
		13	49·74		23	5	32·59			21	15·68		19	3	3·04
		23	45·58			15	28·44		6	7	11·53			12	58·90
	10	9	41·42		24	1	24·28			17	7·38			22	54·75
		19	37·26			11	20·13		7	3	3·24		20	8	50·61
	11	5	33·10			21	15·98			12	59·09			18	46·46
		15	28·95		25	7	11·83			22	54·94		21	4	42·32
	12	1	24·79			17	7·68		8	8	50·80			14	38·17
		11	20·63		26	3	3·53			18	46·65		22	0	34·03
		21	16·47			12	59·38		9	4	42·51			10	29·88
	13	7	12·31			22	55·23			14	38·36			20	25·74
		17	8·15		27	8	51·08		10	0	34·22		23	6	21·59
	14	3	3·99			18	46·93			10	30·08			16	17·45
		12	59·83		28	4	42·78								

The quantities in the ephemeris are to be interpolated directly for the times for which they are required, the equation of light having been already applied.

The position of *Jupiter's* North Pole is assumed to be R.A. $17^h\ 51^m\ 58^s{\cdot}68$, N.P.D. $25°\ 26'\ 13''{\cdot}2$ at the beginning of 1903,

and R.A. $17^h\ 51^m\ 58^s{\cdot}91$, N.P.D. $25°\ 26'\ 13''{\cdot}6$ at the beginning of 1904.

These values differ slightly from those used in former years, as I have now included the correction for precessional shift of *Jupiter's* equator. The effect of this alteration on physical observations of the planet is, however, altogether negligible.

P denotes the position-angle of the northern extremity of *Jupiter's* axis, reckoned eastward from the northernmost point of the disc.

L−O+180°, Λ−O+180° are the jovicentric right ascensions of the Earth and Sun respectively, reckoned in the plane of the planet's equator from O, the point of the vernal equinox of *Jupiter's* northern hemisphere ; B, *B* are the jovicentric declinations of the Earth and Sun above the planet's equator.

The adopted values of the diameters at distance 5·20 are : Equatorial, $38''{\cdot}419$; Polar, $35''{\cdot}945$. The sources from which these values are derived were given two years ago.

The assumed time for light to traverse the unit distance is $498^s{\cdot}92$, this being the same value as that used by Mr. Marth.

d denotes the jovicentric angle between the Earth and Sun.

Q denotes the position-angle of the point of greatest phase, and is reckoned eastward from the northernmost point of the disc. It also gives the position-angle of the shadows of the satellites measured from the satellites themselves.

B′ is obtained from B by the formula $\tan B' = \sec \epsilon_0 \tan B$, where $\sec \epsilon_0 = \frac{a}{b} = \frac{15{\cdot}53}{14{\cdot}53}$. Since B, B′ can never exceed some 3°, we may take the tangents as proportionate to the angles. Hence it suffices in practice to find B′ by the formula $B' = \frac{15{\cdot}53}{14{\cdot}53} B$. B′ is the eccentric angle of the centre of the disc. If we call B″ the jovigraphical latitude of the centre of the disc, then we can find B″ by the formulæ :

$$\tan B'' = \sec^2 \epsilon_0 \tan B \quad \text{or} \quad \tan B'' = \sec \epsilon_0 \tan B'$$

The longitudes of *Jupiter's* central meridian are computed with unaltered values of the rates of rotation and of the zero-meridians in the two adopted systems. The addition of the "Corr. for Phase" gives the longitudes of the meridians which bisect the illuminated disc.

The sidereal periods of rotation corresponding to the two adopted systems are $9^h\ 50^m\ 30^s{\cdot}004$, $9^h\ 55^m\ 40^s{\cdot}632$.

The longitude of the Red Spot, after steadily increasing for many years, was stationary in 1901. In the present year it has diminished very considerably. Mr. H. J. Townshend determined it to be 42°·0 on July 17, and this value is approximately confirmed by other observers. There seems to be reason to believe that the change in its rate of rotation was somewhat sudden, but I have not received enough observations to settle this point.

The spot will probably follow the zero meridian of System II. by about one hour at the commencement of the present ephemeris, but a definite forecast of its behaviour is not possible.

The orbits of the satellites were turned edgewise to us in the present year. L. Bartlett, of 3021 Eads Ave., St. Louis, Mo., reports in the *English Mechanic* for November 7 an observation of the rare phenomenon of the eclipse of I. by the shadow of III. on October 19. The shadows were both on the disc of *Jupiter* at the time, and were seen to become merged into one. On turning to satellite I. it was seen to be losing light rapidly, and at $8^h\ 30^m$ became very faint, but regained its full light 10^m later. (I presume the time used is that of meridian 90° W.) The aperture of the telescope employed was $6\frac{1}{2}$ inches.

The *English Mechanic* for November 21, p. 316, states that mutual occultations of satellites were observed in the island of Syra on August $10^d\ 8^h\ 55^m$ G.M.T., August $13^d\ 7^h\ 35^m$ G.M.T., September $6^d\ 9^h\ 5^m$ G.M.T. The name of the observer and size of instrument employed are, however, not stated, so that we cannot be sure that the phenomena were not merely very close appulses.

A list of times of elongation of the fifth satellite is given in the *Connaissance des Temps*.

It may be mentioned here that the *Connaissance des Temps* for 1899 and following years gives ephemerides for the satellites of *Mars*, *Saturn*, *Uranus*, and *Neptune* in the same form as those formerly contributed to the *Monthly Notices* by Mr. Marth.

I have received a series of longitudes of the Great Red Spot from Mr. W. F. Denning, from which the following mean positions are deduced :—

Date.	Longitude (System II.)	No. of Obs.	Date.	Longitude (System II.)	No. of Obs.
	°			°	
May 23	45·1	3	Sept. 15	39·2	4
July 4	43·9	4	Oct. 13	38·1	4
Aug. 16	41·1	5	Nov. 17	37·9	4

These seem to indicate a somewhat sudden diminution of the longitude towards the end of May. The longitude continued to diminish rapidly throughout the summer, but apparently became nearly steady in October and November.

Mr. Denning found the mean rotation period of the equatorial spots in 1901 to be $9^h\ 50^m\ 29^s{\cdot}1$, and estimates that this year will give approximately the same value.

Benvenue, 55 *Ulundi Road, Blackheath, S.E.*:
1902 *December* 8.